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MEMOIRS AND PROCEEDINGS

OF THE

MANCHESTER

LITERARY & PHILOSOPHICAL

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NOTE.

The authors of the several papers contained in this volume are themselves accountable for all the statements and reasonings which they have offered. In these particulars the Society must not be considered as in any way responsible.

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OF

THE MANCHESTER LITERARY & PHILOSOPHICAL SOCIETY, 1915-1916.

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PRESIDENTIAL ADDRESS.

Animal Symmetry and the Differentiation of Species.

By THE PRESIDENT,

Professor SYDNEY J. HICKSON, M.A., D.Sc., F.R.S.

January 11th, 1916.

In the early years of the 19th century Baron Cuvier constituted four great divisions for the Animal Kingdom: the Animalia Vertebrata, the Animalia Mollusca, the Animalia Articulata and the Animalia Radiata. In the first three of these divisions the organs of sense and motion are symmetrically arranged on the two sides of an axis. In the last division they are disposed like rays round a centre.[1]

This early attempt to establish a system of classification of the animal kingdom based on a separation of animals showing a radial symmetry from those showing a bilateral symmetry never met with any real success. Many of the groups of animals that were included in Cuvier's division Radiata proved to be widely separated from one another by anatomical characters, and some of them, such as the Echinodermes and the Entozoa, proved to be more closely related to bilaterally symmetrical animals than they are to the other Radiata.

But if we recognise, as we must, that body symmetry is not a good guide to a scientific classification of animals, it may be worth while to consider the circumstances that

[1] "Dans tous les précédens, les organes du mouvement et des sens étaient disposés symétriquement aux deux côtés d'un axe. Dans ceux-ci, ils le sont circulairement autour d'un centre." Cuvier. "Le Régne animal," 1817, p. 61.

February 12th, 1916.

led to the evolution of the two principal types of symmetry and the influence that symmetry has had in the differentiation of those smaller discontinuous groups of animals which we call species.

In many of the higher groups of animals, such as the Vertebrata, Arthropoda and Annelida, we find that the body shows an almost perfect bilateral symmetry. If we take such an example as a fish and divide the body vertically in a plane running from the snout to the tip of the tail, we divide the body into two equal parts in which the organs of the one part are almost an exact reflection of the organs of the other part. Moreover, this plane, from snout to tail, is the only plane in which the body can be divided into two equal parts with a similar arrangement of the organs. The bilaterally symmetrical body also shows an anterior end which goes first in movement, and a posterior end which follows, a dorsal surface which is heliotropic, and a ventral surface which is geotropic and a right and left side.

This bilateral symmetry of the animal body is usually accompanied by the power of rapid movement in a definite direction. All Vertebrate animals, Arthropods and Annelida, which possess the power of strong muscular movements in a definite direction through the air or water or on the land, have a definite bilateral symmetry. But this is not confined to animate things. A railway train, a steamship, or a motor car show an anterior and posterior end, a dorsal and ventral surface, and a right and left side. They are also essentially bilaterally symmetrical. It is, in fact, an essential feature of objects that move rapidly and efficiently by their own power that they should have this kind of symmetry.

But although all animals that move rapidly are bilaterally symmetrical, it is also a fact that there are others

of sedentary habit, such as the Cirripedes, Tunicata and Polyzoa, that show a predominant symmetry of the same kind. This symmetry can only be accounted for by appeal to their phylogenetic history. It can be shown in all cases that these sedentary animals with a bilateral symmetry are derived from ancestral forms that had a previous history of free movement in a definite direction. But even in these cases there is a tendency for certain organs, and particularly those that are connected with the ingestion of food, to assume a secondary radial symmetry.

The six pairs of legs of the Cirripede when in use are not arranged in a bilateral series but form an almost regular funnel towards the apex of which the food is passed and the shells frequently assume an almost perfect radial symmetry. Similarly the lophophore of Polyzoa and the tentacles round the mouth of Tunicates usually assume a radial symmetry when in action.

In the Coelenterate we find that the plan of the body is usually that of a complete radial symmetry. This radial symmetry is expressed by the arrangement of the organs along a certain number of rays proceeding from a common centre. The body may be cylindrical, spherical, or disc-shaped or any intermediate kind of solid radially symmetrical form, but there are no ends that we can call anterior or posterior, no right or left sides, and no dorsal or ventral surfaces. We can usually distinguish an oral end or an oral surface where the mouth is situated from an aboral end or aboral surface opposed to it, but it is an inaccurate use of terms to speak of either of these surfaces as anterior or dorsal as is sometimes done.

The radially symmetrical form is always correlated with one of two habits of life, the sedentary habit or the floating habit. As examples of animals of the former habit we may refer to such examples as Hydra, the Sea-

anemone and the solitary coral. A solitary coral such as Caryophyllia is permanently fixed to a solid object at the bottom of the sea and obtains its food by seizing with its tentacles the prey that floats or swims within their reach. We may suppose that in shallow sea water with its constantly shifting currents food may arrive within reach from any point of the compass and the radial arrangement of the tentacles is the most efficient arrangement for catching the food at the earliest possible moment.

In Hydra and in the Sea-anemone there is some power of movement from place to place although the feeding habit is essentially that of sedentary animals. Hydra is perfectly radially symmetrical, with a cylindrical body, a round mouth and a ring of tentacles, but in the sea-anemone there is a subordinate bilateral symmetry shown in the slit-shaped mouth and certain details of the structure of the mesenteries. It would be an interesting study to inquire into the origin of this subordinate bilateral symmetry in the sea anemones and other zoantharia, but, beyond expressing the opinion that it originated at a time when the power of movement of ancestral zoantharia from place to place was greater than it is now, the matter will not be further discussed in this address.

The radially symmetrical form of animal shape, then, is the form that is best adapted for an animal that is fixed to the bottom in still water, or in water with variable currents from all directions. But it is also the form best adapted for an animal that floats or drifts about at or below the surface of the water, and we find numerous examples of perfectly radially symmetrical forms of Heliozoa, Radiolaria, and Foraminifera among the Protozoa as well as of Medusae among the Coelenterata and in the group of the Ctenophora.

The case of radially symmetrical forms is also comparable with certain inanimate objects. I cannot think of any such objects that receive things from all directions as a Sea-anemone receives its food, but many objects that give out things in all directions, which is the same in principal, such as electric light globes, lamp shades, many forms of stoves, etc., are radially symmetrical. Similarly objects that float or drift through the air, as a jelly-fish floats in the water, are radially symmetrical. As an example of this I may mention the old fashioned balloon, which is radially symmetrical in contrast to the dirigible or the aeroplane, which move rapidly by their self contained engines, and are bilaterally symmetrical.

Here again zoologists will be able to point out many exceptions to the general principle I have enunciated. There is the case of many of the Echinoderms for example which show a very pronounced radial symmetry, but freely move about from place to place. But the Echinoderms have certainly a record in their family history of a previous sedentary habit, and their movements cannot at the best be described as rapid. Moreover, in those forms such as the Holothurians, which exhibit a strong development of muscle bands in the body wall, there is a pronounced tendency to assume a secondary bilateral symmetry.

The cases of sedentary animals that are bilaterally symmetrical already referred to, such as the Cirripedes and Polyzoa, might be compared to the old railway carriage which has settled down in a field as a cricket pavilion but still retains its bilateral symmetry.

In comparing animals that are bilaterally symmetrical with those that are radially symmetrical the zoologist observes that there is usually far more variation in the important organs of the latter than in the former. In Hydra for example the only important organs are the

tentacles, but they vary in number from 5 to 10 in specimens of the same species. In the Sea-anemone too, there are similar variations both in the number of the tentacles and in the number of the mesenteries. In the jelly-fish *Aurelia aurita* Ehrenberg had recorded extraordinary variations in the number of rays, of the gastric pouches and of other organs.

All of these variations are what Bateson has called meristic, and do not affect the general plan of radial symmetry.

With bilaterally symmetrical animals on the other hand the variations are far less frequent, and are usually confined to organs of secondary importance It is not necessary to enlarge upon this point in this place because the truth of it must be apparent to any one who has had long experience in a zoological laboratory, but mention may be made of the rarity of any variation from the normal that we find in any of the important organs of the Earthworm, Crayfish, Frog, Rabbit, and other animals that are frequently dissected in the zoological classes.

But this difference as regards variability is just what would be expected. Any variation from the normal in a bilaterally symmetrical animal unless paired or exactly median would interfere with the balance of the body on the antero-posterior axis and impede the rapidity and accuracy of movement. We can understand therefore that in evolution any tendency to variations on an important scale are checked unless such variations are equipoised on the median line, but even bilateral or median variations become rarer as the rapidity and co-ordination of movement are increased. For example, in the slow crawling Annelida variations in the actual number of somites of a species are common but in the more rapid Arthropoda and the higher Vertebrata variations in the

number of body somites are seldom found. It is otherwise with the radially symmetrical animals in which variations from the normal do not in the same way interfere with the movements of the body or power of obtaining food.

But to return to the question of the body symmetries. We have seen that a radial symmetry is frequently associated with the sedentary habit and that this association is probably correlated with the need for collecting food in any direction from which it may approach the animal.

Another method, however, adopted by many classes of sedentary animals for increasing the food catching powers, is by the formation of colonies by gemmation or fission from the original individual developed from the egg.

These colonies, as seen in the Corals, Alcyonaria, Hydroid zoophytes, Polyzoa, Tunicata, etc., are frequently supported by skeletal structures of Calcium carbonate, Chitin or Keratin, frequently attain to a great size and assume an infinite variety of shapes. In many cases the shape may be described as definitely radially symmetry. In any well-equipped Museum there may be seen the large dome-shaped masses of brain coral, the long cylindrical unbranched colonies of Juncella, the bush-like growths of Seriatopora branching profusely in all directions from a common centre, and many other forms that have a more or less complete radial symmetry, but still a very large number of them show a method of growth and branching which is clearly not on a radially symmetrical plan, and the question arises: How can these other shapes be accounted for?

A sedentary colony receiving food for its individual members from all directions should be radially symmetrical, just as a Hydra or a Sea-anemone are radially

symmetrical ; but in the struggle for existence between these sedentary forms of animal life in rock-pools, coral reefs and many other favoured localities at the sea bottom, there is so much overcrowding that unless the colonies are able in their growth to overcome the difficulties of their environment by some modification of a definite symmetrical plan of growth they would be starved and stifled by their competitors. Overcrowding, however, is not the only difficulty that the sedentary colonies have to contend with in the struggle for existence at the bottom of the sea. In localities where the population is not very dense there may be the dangers associated with the silting up of sand or mud, with intense wave action in exceptional storms, with special or peculiar set of the currents and countless other varieties of conditions that are met with at the bottom of the sea. The sedentary colonies have become adapted to these various conditions by strengthening their structures with deposits of calcium carbonate, as in the Corals, by provision for extreme flexibility as in many of the Hydroid zoophytes, alcyonaria and Polyzoa, and by various modifications of their architecture in adaptation to the complex forces that play upon them.

But with all these varieties of form and structure of the colony as a whole the general result has been to bring the individual polyps of which the colony is composed into such a position that their food supply may be expected from any direction, and the radial symmetry of the individual is maintained.

If we take such examples as Madrepora or Millepora among the Corals we find in each genus a very great variety of growth, there are forms with profuse delicate branches and with thick sparse branches, plate like forms, cup-shaped forms, encrusting forms, etc., but the polyps

which build up these great colonial masses are alike in each genus and exhibit an almost perfect radial symmetry. Similarly with the Alcyonaria in which group we find an even greater variety of shape and structure in the colony as a whole there is a most remarkable similarity in the anatomy as well as in the general symmetry of the constituent polyps.

Now if we consider the general structure of these colonies apart from their shape or symmetry, we find that in the first place there is a certain general correspondence between members of the same zoological groups as regards the actual constitution of the skeletal elements. Thus in all the Madreporaria the skeleton is composed of a crystalline calcium carbonate, in nearly all the Alcyonaria the tissues are supported by defined and shaped spicules of the same substance, in nearly all the Hydroid zoophytes the skeleton is formed by secretions of chitin or keratin, so that in a general way the zoologist can determine the zoological affinities of a given specimen by the structure of these common colonial structures. In the second place the details of the structure in the colonial skeletons frequently correspond with the zoological affinities of the individual polyps. Thus the septa of the Madreporaria, the axis of certain Alcyonaria, the thecae of the Calyptoblastea, the minute tabulate pores of the Milleporina, the styles of the Stylasterina, and many other characters can be used with confidence as guides to zoological affinity.

But when we take the shape, the general symmetry, or the method of branching as characters of a sedentary colony, we find as a general rule that they are no safe guides to zoological affinity. The various forms of palmate, plicate, ramose, sub-ramose, foliaceous, and many other types of branching occur over and over again in different genera of Corals, and it is constantly found that

two examples of sedentary colonies that look alike, when placed side by side, may belong to totally different groups of the animal kingdom.

Many examples could be chosen to illustrate this point, but I will mention one which claimed my attention a few months ago. There are two species described by Jullien and Calvert named *Hornera eburnea* and *H. verrucosa*, and placed by them in the Order of the Polyzoa. In examining the Polyzoa collected by the "Siboga" Expedition, Dr. Harmer came across specimens of the same species, but feeling some hesitation about their systematic position sent them to me for examination. A study of the minute structure of the specimens leaves no doubt whatever in my mind that they are as Dr. Harmer suggested, not Polyzoa at all, but members of the order of Stylasterina.

The factors that determine the ultimate form and symmetry of a sedentary colony are probably two, at least, in number. There is a factor determining the general plan on which the colony is to be built up, and there is a factor of plasticity which enables this plan to be modified in various ways according to the environment. Probably these two factors occur in the determination of the exact form of every animal, but the essential point about the sedentary colony is that the factor of plasticity is one of extreme importance as compared with its importance in bilaterally symmetrical animals. The reason for this is obvious. A bilaterally symmetrical animal by its power of locomotion from one locality to another can, to a certain extent, choose its own environment, but a sedentary colony, when once it has fixed itself to its support, must accommodate itself to the ever-changing conditions of environment. A large measure of plasticity, in other words, is a condition of its survival. If it were

unable to adapt its method of growth according to the nature of its support, the number and character of its neighbours in the immediate vicinity, and according to the set of the currents and the food they bring, the species would soon be come extinct.

With this great plasticity in the method of growth and therefore the great accommodation of shape to the conditions of the environment many of the characters used by systematists for the distinction of species must be regarded as of very little value. In many of the genera of corals and alcyonaria I am convinced that there is no series of discontinuous groups comparable with the species of bilaterally symmetrical animals, and I think it is very probable that when we have further detailed information concerning the range of variations of various kinds of Coelenterate sedentary colonies the attempt to subdivide the genera into definite specific groups will be finally abandoned.

If this general conclusion is justified it must be admitted to be one of far-reaching importance, because it will necessitate a very different treatment of the systematic zoology of many groups of Coelenterata to that which is generally adopted; but after many years of laborious work in striving to determine species of these animal colonies I feel quite convinced that we have been engaged in a more or less fruitless task. In some of the genera to which I have paid special attention, such as Millepora, Tubipora, Spongodes (Dendronephthya), Solenocaulon and some others, the evidence afforded by the examination of a large number of specimens from different localities affords no support to any conception of discontinuous species, and in others, such as Stylaster, Errina, Distichopora, Alcyonium, the number of species could safely be reduced to two or three.

Bernard[2] has already come to a similar conclusion as regards certain genera of Madreporaria, and his view is supported by some interesting experimental work by Wood Jones.[3] I may also call attention to the valuable work by Matthai[4] on the corals of the family Astraeidae, in which, by a comparison of the structure of the polyps with that of the hard skeletal parts, he has shown that a very considerable reduction in the number of species attributed to several genera should be made.

Many years will probably pass before zoologists arrive at a common agreement to abandon the present system of making species in these groups, but the results of all recent investigators point irresistably to the conclusion that whatever limit we make to the extension of a specific group, the species of these sedentary colonies are far more variable than the species of the free bilaterally symmetrical animals. A question of more general interest however is whether there is sufficient evidence that the difference in variability of the species in a group of animals which show a series of gradations from a radial to a bilateral symmetry. We have such a group in the Sea-pens or Pennatulacea and it has been my good fortune to have an opportunity of studying in detail specimens of nearly all the known genera and a large proportion of the known species.

The Alcyonaria belonging to the Order Pennatulacea form colonies which are not attached to stones or rocks, but are free and capable of a certain amount of movement in the mud at the bottom of the sea. As nearly all the Sea-pens are found in deep water we know very little

[2] Bernard, H. M. *Proc. Camb. Phil. Soc.*, 1901, xi., p. 268; and *British Museum Catalogues*, *Madreporaria*, Vol. IV., 1903.

[3] Jones, F. Wood. *Proc. Zool. Soc.*, 1907, p. 518.

[4] Matthai, G. *Trans. Linn. Soc.*, XVII., 1914.

about their powers of movement, but judging from their anatomical structure it is clear that some kinds are a great deal more mobile than others. Now in this Order we find a series of forms beginning with the Veretillidæ, which are radially symmetrical, and ending with the Pennatulidae which are bilaterally symmetrical. Between these two extremes there is a number of families showing a gradual increase in the intensity of the bilateral symmetry.

The systematist who begins his studies with the radially symmetrical Veretillidæ finds the group exceedingly difficult on account of the extraordinary variability of the recognised species and genera, and the way they run into one another. This great variability is seen in the shape of the colony, the size of the zooids, the size and shape of the spicules and in the colour. As an example of this I may refer to the illustration given in my memoir[5] of the spicules of three specimens of *Cavernularia orientalis* taken from the same locality in shallow water at Amboyna. Attention may also be called to the remarkable variations of *Actinoptilum molle* from the Cape of Good Hope, described by Dr. J. Stuart Thomson in a recent memoir published by this Society.

In this family, too, we find that the axis which is invariably present and of a definite kind in the bilaterally symmetrical groups may be absent, imperfect or complete in closely related species.

Passing on to the family Kophobelemnonidæ, which shows the beginnings of the bilateral symmetry, we find in some forms, and particularly in those species with the bilateral symmetry less well developed, a similar variability. For example, in specimens of *Sclerobelemnon Burgeri* from Molo Strait the spicules have an extra-

[5] "Pennatulacea of the 'Siboga' Expedition," fig. 9, p. 53. (In the Press.)

ordinary variability in shape and in size (V. "Siboga" Monograph, fig. 18, p. 84). But when the systematist comes to deal with some of the families that show a pronounced bilateral symmetry he finds that the species are far less variable as regards certain specific characters, and the species are well defined. In the genus Pennatula, for example, such species as *Pennatula Murrayi*, *P. Naresi*, *P. grandis*, and others, are perfectly well defined, and can be easily identified. The spicules taken from a particular part of the colony have a constant form—the 3-flanged spindle—and within certain limits a constant size. Moreover, the axis, the arrangement of the zooids, and even the colour, are far less variable than they are in the Veretillidæ. Similarly with the genus Scytalium, the spicules are extraordinarily constant both in size and shape, and the few species are comparatively well defined.

Of course there are difficulties even in these bilaterally symmetrical Pennatulacea, witness the variability in the shape of the leaves of *Pennatula phosphorea*, and the variability as regards certain characters of the genus Pteroeides, but these difficulties are trifling compared with those that occur in the radially symmetrical groups.

In these few pages I have summarised the general results of many years work on the structure of the Pennatulacea, but a great many more illustrations could be given to indicate the way in which the gradual change from a radial to a bilateral symmetry has been accompanied by a decrease in the variability of certain structures, and the gradual differentiation of smaller discontinuous types of colonies which are known as species.

We are still in ignorance of the extent to which the assumption of bilateral symmetry is accompanied by an improvement in co-ordinated movements of the colony as a whole, but speaking generally we do find that the

bilaterally symmetrical forms are provided with a more powerful and a more elaborate muscular system, particularly as regards the rachis than the radially symmetrical forms, and this indicates that the assumption of the bilateral symmetry is correlated with increased powers of locomotion.

Nor are we better informed as to the evolutionary history of the group. The ancestral form may have been a fixed sedentary colony or it may have been a floating colony. For reasons I have given elsewhere I believe that it was a floating colony, but in either case it was undoubtedly radially symmetrical.

It seems to me that these studies on the structure of the Pennatulacea afford a very interesting and instructive example of the way in which variable or plastic characters may become less variable or rigid as we pass from the radial to the bilateral symmetry and of the way in which the increasing rigidity of certain characters leads in some cases to the differentiation of the discontinuous groups which are recognised as species.

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I. The Relationship between the Geographical Distribution of Megalithic Monuments and Ancient Mines.

By W. J. Perry, B.A.

(Communicated by Professor G. Elliot Smith, M.A., M.D., F.R.S.)

(Received and read October 5th, 1915.)

The aim of this communication is to set forth some results of a preliminary survey of the facts in one department of the general investigation with which Professor Elliot Smith and I are at present occupied. Dr. Elliot Smith has already presented before this Society some of the evidence concerning the spread of the megalithic culture and the elements of which that culture is composed.[1] In the discussion on "The Influence of Egyptian Civilisation upon the World's Culture,"[2] which he opened at the Manchester meeting of the British Association of this year, Dr. Elliot Smith put forward a list of the elements of the megalithic culture. Under the headings (*f*) and (*g*) he stated that the carriers of the culture "practised weaving linen, and in some cases the use of Tyrian purple, pearls, precious stones and metals and conch-shell trumpets, as well as the curious beliefs and superstitions attached to the latter"; and (*g*), "adopted certain definite metallurgical methods, as well as mining."

[1] *Manchester Memoirs*, July, 1915: republished under the title "The Migrations of Early Culture." Manchester University Press, 1915.

[2] *Report Brit. Assoc.*, 1915.

November 24th, 1915.

Map I.—Showing the distribution of megalithic monuments (stippled areas) according to Fergusson, and the sites of ancient mines, gold (circular spots), tin (T), copper (square spots), and silver (triangular spots).

Certain considerations have led us to add these elements to the megalithic culture. Some of the facts in justification of this will now be placed before you. The material included in this paper must be regarded as forming a rough preliminary sketch of a larger scheme. Some time must elapse before it will be possible to present the case with any approximation to completeness, or to cope with the inevitable complexities, and follow out the extensive ramifications which always result from the examination of new problems. Many lacunæ will at once be detected, but their presence is due to adventitious circumstances and not to difficulties which cannot be overcome. The facts quoted are those which have been accumulated by independent workers: they have not been chosen to fit any preconceived theories. On the contrary, the facts themselves were of so remarkable a nature as to call for some explanation; and the aim of the present communication is to indicate that when the data are set out impartially they themselves suggest the explanation.

Map I. shows France, Spain and Portugal. On it the distribution of megalithic structures as given by Fergusson[3] is represented by stippling. If it be objected that in using Fergusson's map we are quoting an author with whose views we are in sympathy, it may be explained that Fergusson's map represents concrete facts admitted as true by those who differ from him as to their meaning.[4] The distribution is peculiar and quite unmistakable in its definite localisation. On the same map is plotted out the distribution of ancient pre-Roman and pre-Greek mine-workings and metal-washings in those countries.[5] It will be seen at a glance that there

[3] "Rude Stone Monuments." London, 1872.

[4] See for example H. Westropp, *Journ. Ethnological Soc.*, London, 1869, and Lane Fox's (Pitt-Rivers') comment upon his theories.

[5] Gowland. *Roy. Anth. Inst.*, XLII., 1912.

is complete coincidence. The distribution of megalithic structures as given by Fergusson is the same as that of the earliest seats of the metal industry which have yet reported in these three countries. The extraordinary nature of the pattern produced by the distributions, round the coast of Spain and Portugal and right across France, make it difficult to refuse to recognise the intimate relationship that must exist between the building of megalithic structures and the getting of metals.

An enumeration of the localities of ancient mines in the region under consideration will serve to make the matter more convincing.[6] Gold has been worked or washed for in Asturias, Galicia, the basins of the Sil, Ebro, Tagus and Douro ; at Cordova, on the coast region of Malaga and from Malaga to Cartagena ; in Andalusia. In France, again, gold workings have been discovered in the basin of the Adour, in the northern Pyrenees, Limousin, Creuse, and Maine-et-Loire, some of the excavations being remarkable for their size. De Launay remarks that, "in the central plateau, at many points which in many cases still retain the name of Aurière, the trace of ancient detritus has been found where most probably auriferous sands must have been washed" (p. 89). Siret has also demonstrated that most probably gold was formerly washed in Morbihan and round the mouth of the Loire (*ib.* 19, pp. 140 *e.s.*).

This distribution is, in itself, well representative of that of the megalithic structures. I shall have occasion later to insist upon the wide distribution of gold workings in the megalithic area.

[6] My authorities are : Gowland, *Journ. Roy. Anth. Inst.*, XLII., 1912 (Huxley Memorial Lecture, "The Metals in Antiquity), *Arch.*, 55, 56, 57 ; De Launay, "The World's Gold" ; L. Siret, "Les Cassiterides et l'Empire colonial des Phéniciens," *L'Anthropologie*, Vols. 19, 20, 21 (1908-1910) ; O'Reilley, *Proc. Royal Irish Acad.*, 1900-2 ; C. W. King, "Precious Stones and Metals," London, 1865.

Copper was formerly worked in southern Spain and Asturias. Tin was formerly worked in Spain and Portugal, in Orense, Pontevedra, Beira, Minhos, Tras-os-Montes, Salamanca, Cartagena and Almeria: in France in Loire, Morbihan and Limousin. Cartagena, Linares and Almeria were the chief centres of silver and lead mining in Spain.[7]

Thus in three countries the mining districts were those which contained megalithic structures. But, before proceeding, one point must be made quite clear. The aim of this grouping of facts is to demonstrate one thing only: the coincidence in certain regions of the distribution of the megalithic culture with that of ancient mining operations. No assumptions whatever are made as to chronology. Where the authorities report ancient mines, that fact is indicated on the map. Without doubt some workings are later than others, but at present we are not concerned with that. As far as the chronology of the cultural intrusions into Spain and Portugal is concerned, I am willing at present to accept the views of M. Siret as a tentative working hypothesis. But the fact remains that in all this welter of Neolithic, Celt-Iberian, Greek, Roman, and other influences, which in varying degrees played their part in the history of the Iberian peninsula, one fact stands out quite clearly—the exact coincidence of megalithic structures with the earliest seats of the metal industry. The question as to the identity of the people who were responsible for the megalithic structures in various parts of the world and the complex culture associated with them may also be left in abeyance for the present. But so far as the special problem of South

[7] In the Oxford School Economic Atlas silver and lead mines are seen to occur along the track of the megaliths (p. 62) in France, and the distribution in Spain is strikingly like that of megalithic structures.

Western Europe is concerned I am in full accord with M. Siret as to the identity of the carriers of the megalithic culture into Spain. However, this paper is concerned wholly with distributions, and all questions concerning the why and the wherefore are left on one side for the present.

It would be exceedingly interesting if such a detailed survey as is available in the case of Spain and Portugal could be instituted for the rest of Europe. But, unfortunately, I have not yet had the time to collect the necessary information. I may perhaps be allowed to mention that the same correspondence seems to hold in the case of England and Wales. In the latter country the counties where megalithic structures abound are precisely those where mineral deposits and ancient mine-workings occur. In England the grouping in Cumberland, Westmorland, Northumberland, Durham and Derbyshire is precisely that of old mines; in Cornwall the megalithic structures are mainly grouped west of Falmouth, precisely in that district where mining has always been most active. In the case of Ireland, information (derived both from archæological researches and from folk-lore) is now coming to hand which promises to make the identification of the carriers of the megalithic culture and their association with gold mining most exact. The absence in large parts of the British Isles both of megalithic structures and of old mines, not to speak of mineral deposits, is a most striking and conclusive negative complement to the positive evidence provided by their presence and coincidence elsewhere.

Leaving Europe on one side for a moment, let us turn our attention to other parts of the megalithic region. In this respect Africa is an area of extraordinary interest. The regions of megalithic influence which are most defi-

nitely marked upon the maps which Dr. Elliot Smith has included in his work[8] are Tunis, Algiers and Morocco, the West African Coast, and South-eastern Rhodesia. Ancient mine-workings have been discovered in the north African region[9] and in Rhodesia[10], while Herodotus tells us that the Phœnicians went round to West Africa for gold[11]. The distribution of ancient mines or washings is therefore the same as that of megalithic influence. The presence of gold in large quantities in Madagascar is also significant in view of the presence there of megalithic influence in a pronounced form.

India is another megalithic region which is peculiarly instructive. The distribution of megalithic structures, as given by Fergusson, Meadows Taylor, and Crooke[12] is quite definite and peculiar (*Map II.*). They are very common in the basins of the Godavari and Krishna rivers, all along the eastern and western Ghats, and as far north as the Vindhya hills. Typical megalithic structures are found in Chota Nagpur and Assam.[13] All along the Himalayas, in Khashmir, Nepal and Bhutan, in the Punjab, Rajputana, Sind, as well as in Thibet, we find traces of the culture which Dr. Elliot Smith and I claim to be identical with that of the megalithic people of South India. The great sun temples, the menhirs, stone seats, terrace-cultivation, sun-origin, and many other things, all point to the

[8] "The Migrations of Early Culture." Manchester, 1915.

[9] Freise. "Globus," XCIII., 1908.

[10] Hall. "Great Zimbabwe."

[11] The whole question is discussed in great detail by Dahse in *Zeitsch. f. Ethnol*, 1911, p. 1 *et seq.*

[12] *Op. cit.* "The Rude Stone Monuments of India." *Proc. Cotteswold Naturalists' Field Club*," XV., Pt. 2, 1905.

[13] P. R. Gurdon. "The Khasis." Sarat Chandra Roy, The Ho Mundas of Chōta Nāgpur 1912, The Orāons of Chōta Nāgpur, Ranchi, 1915. The existence of the megalithic culture in Assam will be discussed in my forthcoming work on The Megalithic Culture of Indonesia.

presence there of a cultural influence of a kind closely allied to that of southern India.[14]

Copper was formerly extensively smelted in large quantities in South India, Rajputana, Chota Nagpur, and

Map II, to show the distribution of megalithic monuments (stippled areas), ancient gold (circular spots) and copper mines (square spots), diamonds (lozenge spots) and other precious stones (crosses).

in places on the outer Himalaya, such as Kullu, Gharwal, Nepal, Sikkhim and Bhutan.[15] Gold was formerly pro-

[14] Oldham. "The Sun and the Serpent." London, 1905.

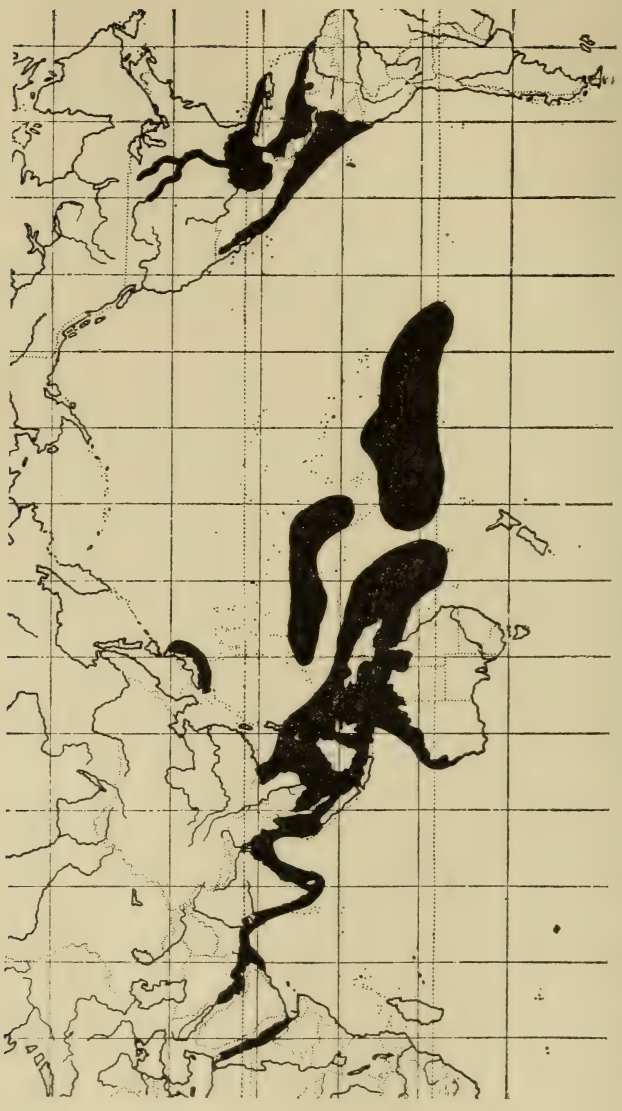
[15] Schoff. "The Periplus of the Erythrean Sea," p. 151. New York, 1912: Gowland. *Journ. Roy. Anth. Inst.*, XLII., 1912.

duced in large quantities in the Chota-Nagpur plateau: also from Thibet, the gold produced there being called 'ant-gold': and in Assam and northern Burma. The rulers of Assam used formerly to require their subjects to wash for gold during a certain number of days each year.

Three great centres of diamond-getting are reported in India. The first constitutes the valleys of the Godavari and Khrishna rivers; the second is the Chota-Nagpur region, and the third is in the Vindhya Hills. Precious stones were found in various parts of southern India and pearls were got from the Malabar coast and from Ceylon.

The distribution of megalithic structures in India therefore corresponds with that of ancient gold-mining, and the sources of pearls, diamonds and other precious stones. This is clearly shown in the map (*Map II.*)

The association between megalithic structures and the early mining of certain forms of wealth serves to throw a flood of light upon the cultural history of India, and should serve as a basis for future research. The support which is afforded for the conclusions suggested by the European coincidences is precise and even startling in its nature. Once again we see that the two general distributions, mines and megalithic culture, agree one with the other. But other considerations now force themselves into the argument. South India and Ceylon are places where immense quantities of precious stones and pearls were exported to the west. A great trade existed in these things at the time when Dr. Elliot Smith and I suppose that the great megalithic wave first set out from Africa for the American coast, and a consideration of the facts in India would lead to the association of precious stones and pearls with megalithic structures. We are



Map III.—Showing the distribution of pearl-shell.
(Taken from the Oxford School Economic Atlas.)

indeed told in Oldham's work (p. 61) that the Naga people of southern India lived under the sea in a place called the land of gems ; there they had trading ships and fished for pearls. We can therefore include pearl-fishing among their activities.

The admirable volume by Ball on the Economic Geology of India (Vol. IV. of the Manual of the Geology of India, 1881,) has come to hand too late for use in this paper. It is a storehouse of precise and detailed information upon the distributions of ancient mines in India. When a detailed distribution of megalithic structures has been made out it will be possible to test the facts much more stringently. I hope to be able to proceed to this task shortly. At present it would seem that the two distributions, megalithic influence and ancient mines, will coincide with great exactness.

Keeping in mind the implied association between the megalithic people and pearls, the next map (*Map III.*) becomes of great interest and importance. With one or two exceptions it is a map of the littoral distribution of the megalithic culture in the Indian and Pacific Oceans : it is also that of the distribution of pearl-shell oysters. In an area from the Red Sea and Persian Gulf right away to the West Indies, the megalithic culture occupies the region of pearl oysters. Both are present in the Red Sea and Persian Gulf, India, Indonesia, Japan, the Caroline and Marshall groups, Melanesia and certain parts of Polynesia,and on certain portions of the American coast.

In the map, which is based upon one found in a school-atlas, no indication is given of the presence of pearl-shell on the coasts of Zanzibar and Madagascar, two localities which are suggestive when the presence of megalithic monuments in Rhodesia and Madagascar is recalled.

Pearls and pearl-shell are found on the West Australian coast, but so far as I know, no trace of megalithic influence is to be detected there. This fact I note, but have no comment to make upon it at present. It is, however, a striking commentary on the thoroughness of the search carried out by the megalith-builders that in their exploitation of the whole world they seem to have missed only one pearl bed, that at Broome, in Western Australia. In South America the megalithic area overlaps that of pearl shells, but on the other hand, it is very closely defined by that of deposits of metals and precious stones. In America the geographical distributions of pearls and megalithic culture coincide with remarkable precision. Peru is the only exception to this generalisation.

Most of the area of distribution of megalithic influence has now been surveyed. From Britain to America the general relationship between megalithic structures and the getting of metals, pearls, and precious stones has been established.

In the Baltic area, however, a new aspect of the problem presents itself. Amber is an article of ornament which is of great antiquity. It is found in conjunction with megalithic structures in such places as Spain, France, Britain, and elsewhere, which shows that the builders of such structures were acquainted with the substance. Siret makes a statement regarding amber which is of great importance (20, pp. 138-142). According to him, amber, jet, callais, ostrich egg-shell, elephant- and hippopotamus-ivory are found in Neolithic stations in Spain. "On ne les trouve pas aux phases anciennes de cette civilization, et sauf un peu d'ivoire il n'y en a plus de traces à l'âge du bronze . . . . Plusiers d'entres elles reparaissent dans les colonies tyriennes (p. 142).

Amber came from Holland, Sweden, and the Baltic

coast, particularly between Königsberg and Memel, and from Denmark.[16] The Baltic distribution is therefore that of megalithic structures: places such as Finland, the Gulf of Bothnia in the Baltic, and the North and North-Western coasts of Norway being devoid of amber and of megalithic structures. Moreover, the inland distribution of megalithic structures in South Sweden and Norway agrees very well with that of mineral deposits: I am unable to say whether ancient mine-workings have been found there. The coincidence of the distribution of megalithic monuments and the sources of amber does not prejudice the consideration of the routes by which amber reached the Mediterranean: it merely suggests as a possibility that the people who controlled the obtaining of amber were megalith-builders.

The consideration of the places whence amber was obtained in the past suggests a possible further development, one, however, which presents enormous difficulties: but as it concerns a region of ancient mining it cannot be ignored. Amber ornaments and beads have been found in considerable quantities in the lake-dwelling regions of Switzerland and Upper Austria and the Terramara settlements of Italy. These settlements range from the earliest Neolithic cultural phases down to dates well within the Christian era. It is commonly believed that this amber came overland from the Baltic and that the Terramara people reached Switzerland and Upper Austria from the Danube basin[17], but certain other considerations cannot be disregarded. The main thesis of Dr. Elliot Smith and myself is that Egyptian culture has had an enormous effect upon the civilisation of the

[16] Streeter. "Precious Stones and Gems," p. 240, *et seq.* London, 1898.

[17] T. E. Peet. "The Stone and Bronze Ages in Italy and Sicily," 1909, p. 510.

earth. It is therefore significant to find many traces of such influence in the earliest Neolithic lake settlements of Switzerland. In the great work of Keller,[18] which cannot be altogether ignored, even if it was published more than forty years ago, some information is given by Dr. Heer which seems to place beyond doubt the fact that Egyptian influence was exerted in a very definite way in the region under consideration. Perhaps I may be allowed to place the facts once more before you. The lake dwellers grew barley, and it was the same variety as that of Southern Italy. Barley is also found in ancient Egyptian graves, even as early as the oldest Predynastic period.[19] Keller adds "further . . . . . a kind of wheat, which is still very commonly cultivated in Egypt, and yet is found in very ancient mummy cases, came at least occasionally, into our districts. The Indian millets have also very probably been introduced in the same manner; they were much cultivated in Egypt, and the Setaria (Fennick) is represented on a tomb of Ramses Sethos and at El-Kab." He goes on to say that "the lake colonists . . . . were also clothed in the same manner, for in Egypt flax took the first place amongst the plants used for spinning and weaving . . . . The cultivation of flax and the art of weaving the thread may frequently be seen on the Egyptian mural paintings, while hemp was unknown as a plant for making thread, and it is also entirely unknown in the remains of the lake dwellings . . . ." a remarkable thing when we remember that both the Greeks and Romans grew hemp. Again, the weeds of the fields betray the origin of the cereals. Dr. Heer says that "a fact of great interest is the occurrence of the Cretan catchfly (*Silene cretica*, L.) in the remains of the lake dwellings, as it is not found in

[18] "Lake Dwellings." 1878.

[19] G. Elliot Smith. "The Ancient Egyptians," 1911.

Switzerland and Germany ; but, on the contrary, is spread over all the countries of the Mediterranean, and is found in the flax fields of Greece, Italy, the South of France and the Pyrenees. The presence of the corn bluebottle (*Centaurea cyanas*) is no less remarkable, for its original home is Sicily. As it had already appeared in the corn fields of the lake dwellings, it indicates the way by which the corn had come into the hands of the colonists.[20]

A converse statement can be added to this remarkable series. Dr. Heer says that "the inhabitants of the lake dwellings do not appear to have had any close connection with the people of Eastern Europe, for they, at least in the bronze age, cultivated rye, with which the lake settlers must have been acquainted if there had been any mutual intercourse."[21] Add to this the use of head-rests, jade, the existence of terrace-cultivation in Switzerland and the Appenines, and many other things, it is only legitimate to conclude that Egyptian influence must have been prominent in this region from the beginning.

I do not propose to discuss the chronology of the settlements, but shall confine myself to the statement that they are situated near the sites of early mining operations. Copper mines have been found at Salzburg, within reach, as Professor Gowland says, of the lake dwellers of the Mond See and Atter See : iron workings were found near Hallstadt and Laibach. In the Jura Alps numerous iron-workings have been found well within reach of the lake dwellers, and copper mines were worked in the Bernese Alps. Another copper working was found at Mustchenstock, within reach of the lake dwellers of Robenhausen.[22]

[20] Vol. I., pp. 524 *et seq.*

[21] *Ibid.* p. 524.

[22] Gowland. "The Metals in Antiquity." Huxley Memorial Lecture. *Journ. Roy. Anth. Inst.*, XLII., 1912, p. 244

"The Early Metallurgy of Copper, Tin, and Iron in Europe." *Archæologia*, 56, 1899, p. 309 *e.s.*, Keller, p. 60.

Two large groups are thus left—the group round Lake Constance and the Terramara group of Italy. Here we seem to be at a standstill until we remember that all the rivers running into the Po still contain gold, and the basin of the Po was famous in antiquity for its gold washings; it is the only river in Italy which was so famed. The Helvetii were said to wash their rivers assiduously for gold and the sands of the Rhine, below Basle, are still washed every summer for gold dust by the peasants of the Grand-Duchy of Baden.[23] Lake Constance gives rise to the Rhine, and therefore the relationship between the pile dwellings and the gold is suggestive, but the distribution of the Terramara settlements is most precise. They are simply all crowded together in the Po basin, and are not found at all in the regions to the north and south.

I am quite well aware of the great complexities of the problems which are presented by the lake dwellings and Terramara settlements, and it must be clearly understood why reference is made to them here. Once the distribution of the earliest mining and washing settlements are under consideration, it becomes impossible to ignore Switzerland and Upper Austria, regions whose early workings are well known. A survey of terrace-cultivation, undertaken before I had any idea as to the existence of such correspondences as are now put forward, had revealed the existence of terrace-cultivation in the Rhine valley, Switzerland and the Appenines, places rather outside the area which Dr. Elliot Smith and I had mapped out for the megalithic culture. It could not be decided whether these terraces were ancient or modern, but the discovery that Tuscany, Switzerland, and the Rhine all came within the mining region at once gave

[23] Keller, p. 60. King, "Precious Stones and Gems," 104, 108.

rise to the suspicion or, at any rate, the possibility that the terraces were of ancient origin, and that the same cultural influence was at work in this region as in other places. This suspicion was further strengthened when it appeared that other signs of Egyptian influence were present. That the inhabitants of the lake-dwellings should have used cereals which undoubtedly were of Egyptian origin, and that they were, on the other hand, ignorant of rye, is surely a fact of the utmost significance. The food of a people is an item of fundamental importance ; the transition from hunting to agriculture is not made spontaneously, as we have been told, but some definite cause, generally cultural, must be assigned for such a change.

Even those settlements in Switzerland where no traces of metal have been found, show signs of contact with relatively advanced cultures.[24] Later on in the same volume the relationship of the pile-dwelling culture to that of the Eastern Mediterranean is again discussed, and words are used which I quote as expressing exactly my present position. "When we speak of Egypt, as we again and again have had occasion to do, we naturally are not thinking of a direct intercourse between the lake colonists and this country, but we simply mean to state that it was the home of that civilisation which spread so widely amongst the regions of antiquity, and which had probably extended over the shores of the Mediterranean further inland from their colonies, so that from these original centres of the civilisation of that age, some scattered rays may have reached even to our lake dwellings."[25]

The almost complete absence of megalithic structures

[24] Keller, pp. 88-9. 469 *et seq.*

[25] *Ibid.* p. 526.

is one fact which will have to be explained, even if other elements of the megalithic culture or signs of Egyptian influence be present. Nevertheless it is a fact that these settlements are so situated as to be near mines or gold washings, and their culture exhibits signs of Egyptian influence. There the matter must rest for the present, and all questions as to the date of colonisation or the means by which the Egyptian influence got there—whether it was brought by those who came to work the mines or in any other way—are left untouched.

Thus far the distribution of old mine workings and of the cultural influence have occupied us. But before drawing conclusions—which must by now have become evident—I propose to go one step further and to occupy myself with the technique of mining, smelting and refining of metals. For this I shall have to rely entirely upon the writings of Professor Gowland, who, everyone must admit, will be a perfectly safe guide. It will be seen that Professor Gowland considers the mining and smelting operations of Switzerland and Upper Austria as well as those of other places where there is more convincing evidence that Egyptian influence has been present. It must not be thought that I am claiming Professor Gowland as a supporter for the thesis which I am putting forward. On the contrary, we are, as it were, viewing his facts from a different angle. It must be remembered that we are considering the relationship between old mine-workings and the megalithic culture, and are not trying to determine the evolution or development of the metallurgical art. But at the same time the statements of Professor Gowland seem to afford very strong support to our thesis. I shall keep to his own words as far as possible so as to avoid any possibility of personal misconstruction.

He first of all discusses Japanese operations. "The method which was practised, and the furnace employed by the early workers, still survive in use at several mines in Japan at the present time." The furnace consists of a hole in the ground, "yet," says Professor Gowland, "by means of it until a few years ago all the copper, lead and tin produced in the country was obtained, ..."[26]

The furnace had no hole in it, but the blast was led in from the top, in the manner, say, of blowing over the surface of water in a bucket by means of a pair of bellows. The metal is not removed by a ladle, but water is sprinkled on its surface with a straw brush. This causes a thick layer to solidify. This is raised by a hook, removed in a shovel, and then thrown into water. The furnaces of Korea are similar. Copper, when smelted, is allowed to remain in the furnace until it is nearly solidified, when it is brought out, placed upon a large stone, and broken up by hammers. "In this case," says Professor Gowland, "the pieces of copper are identical in structure with those of European copper hoards." He goes on to say that—"The copper thus produced in Japan is never cast direct from the smelting furnaces into useful forms, but is always re-smelted into crucibles, a mode of procedure which undoubtedly prevailed in Europe during the early Metal and the Bronze Ages.[27]

"The crucibles used by the Japanese for this purpose are very much larger than those employed during these periods in Europe, and are also of an entirely different shape. Yet, in composition, being made of ordinary clay, mixed with chopped straw and chaff, they are precisely analogous to those found in the pile dwellings of the Swiss and Upper Austrian lakes.

[26] Gowland. *Arch.*, 56, p. 276.

[27] *Ibid.* pp. 276 *et seq.*

"The process of melting the copper in these crucibles differs *in toto* from that practised in any other country in modern times; but, as we shall see later, it is exactly the same as that by which prehistoric man melted copper and bronze for casting his rude implements of these metals. It is hardly necessary to point out that in melting metals at the present day the crucible is imbedded in the fuel of the furnace, the heat necessary for their fusion being applied to its exterior. In the Japanese process, however, the exterior of the crucible is not heated, but the fire is made in the crucible itself and above it" (Gowland, *op. cit.*, p. 281). The blast is led over the top of the crucible. "The exterior of the crucible when taken out of the furnace is barely red-hot. The effects of the high temperature are only visible on the upper part of the rim and in its interior, exactly what we find in the crucibles and melting spoons of prehistoric man"[28] "Should the copper ore treated by the Japanese smelting process contain foreign metals such as tin, arsenic, antimony, nickel and lead, the resulting copper will contain these metals in varying proportions according to the quantities of each which may have been present in the ore. Similarly, and for the same reason, these metals are also found in the celts and other early objects of copper in Europe."[29] Professor Gowland gives a table which records the analysis of objects taken from various places: "those given are representative types, and are amply sufficient to show how closely analogous in composition the Japanese copper is to that of prehistoric times in Europe. The average percentage of copper is practically identical in both series, the nature of the impurities only being different, and the proportion of sulphur higher in

[28] Gowland. *Op. cit.*, p. 281.

[29] *Ibid.* 282.

the Japanese examples." Such a comparison is not without value, as, although it does not prove with certainty that the process and furnace used by prehistoric men in Europe was identical, yet it affords some evidence in favour of the view that they were not very widely different.[30]

The lumps of copper of the period of the Bronze Age have the columnar structure, caused by breaking the metal when it is just on the point of solidification. Professor Gowland says "This proves inconclusively that the mode in which the copper had been removed from the furnace is identical with that practised in Korea, as already described." The cakes found are fragments of rough plano-convex disc-shaped masses, of diameter 8-12 ins. and greatest thickness 1½ ins. "This would indicate that the smelting furnace in which copper was then extracted from its ores was a shallow conical or hemispherical hole . . . resembling the primitive furnaces of Japan."[31]

Professor Gowland says that "the mines of Salzburg were undoubtedly worked in the time of the lake-dwellings of the neighbouring Mond See and Atter See. The furnace which Dr. Much found there is, according to Professor Gowland, "exactly similar to the Japanese smelting furnace, excepting that it was built above the ground level ; and was worked in the same way, that is, the blast was led into it over its upper edge, and its contents, both of slag and copper, were removed from its open mouth, as in the Japanese practice."[32]

The crucibles were everywhere made of the same substance in the earliest times. Moreover, the sides are so thick and the clay so fusible that it is impossible to melt copper or bronze in them, by the application of

[30] *Ibid.* 283.
[31] *Ibid.* 285.
[32] *Ibid.* 285 *et seq.*

external heat, or by embedding them. The metal was refined in them in the same way as in Japan. They are put in the ground and a fire is piled up over them and urged by a blast. "In consequence of this mode of heating, the lower parts of these vessels will, it is evident, bear little or no traces of the action of heat, although the upper edge and interior may exhibit a semi-fused vesicular structure, and this is precisely what we find in all these early crucibles."[33]

The Japanese method of getting water out of a mine is also, according to Professor Gowland, the same as that employed in ancient European mines, the water being baled into successive tanks.[34]

Professor Gowland has some very interesting remarks about iron furnaces. The furnace which was used by the ancient Egyptians, which was also used 60 years ago in the Sudan, agrees "very closely with the Japanese furnace for copper, tin, lead, and to which it is similar in form." He goes on to say that "the furnace which was employed by the Etruscans at a very early date, both in the island of Elba and on the mainland, is very closely allied to the furnaces of Kordofan .... that the Etruscan furnace had its origin in Egypt does not at present admit of absolute proof .... From metallurgical considerations only, we would certainly be led to the inference that the Etruscans had obtained their knowledge of the method of extracting the metal from that source."

"Closely analogous to the ancient furnace of the Etruscans, in fact, in its early form identical with it, is the Catalan furnace of the Pyrenæan region of the north of Spain and the south of France, which has been in use from very early times up to our own day. That it had an

[33] *Ibid.* 290.
[34] *Ibid.* 270.

independent origin in that locality cannot be reasonably maintained, and I think we may hold, on the strongest grounds of probability, that it was introduced from the Elban region during some part of the Etruscan age. In connection with this it is worthy of notice, that in the Mediterranean of Europe, west of the Apennines, no other type of iron furnace has ever been in use until modern times. In other parts of Europe it was also employed to a certain extent, but was not usually the most important form."[35]

As regards the British iron mines, "The ancient slags are of the same nature and composition as those produced in the Roman period, and although they do not contain Roman remains neither have they been found in direct association with British objects" . . . . I am of the opinion that the iron furnaces of Britain before Roman times, and long afterwards, were simple low hearths, resembling the Catalan furnace. The fuel was charcoal, and the "bloom" of iron was taken out from the top of the furnace . . . "[36]

"Respecting the source whence Britain first derived its furnace and the method for the extraction of iron from its ore, I think we may reasonably conclude . . . . . that it was the Mediterranean region of Europe, either the Eastern Pyrenees or north-west Italy."[37]

Speaking of the smelting of iron in general he says "The actual process for the extraction of iron from its ores in Europe, in fact, in all countries in early times was practically the same."[38]

I do not propose to enter here into a discussion of the smelting of iron. One important fact must be con-

[35] *Ibid.* 312 *et seq.*
[36] *Ibid.* 314.
[37] *Ibid.* 314.
[38] *Ibid.* 310.

sidered in the future. Two distinct forms of furnaces are known: that, already mentioned, which is found in Europe west of the Apennines; and another, in which the blast is led in at the bottom, which is found to the east of the Apennines.[39] The comparative lateness of iron smelting in many places makes it quite unnecessary to examine the matter here, pregnant though it is with possibilities.

The statements of Professor Gowland which I have re-produced here make it quite clear that he considers the whole process of obtaining metals by mining and smelting to have been essentially the same everywhere in ancient times. The furnaces employed were similar: the crucibles were of the same material and generally of the same form: the process of smelting, first in the furnace and then in crucibles was found everywhere, even persisting down to present times in the absence of any fresh cultural influence.

The study of the technique of mining and smelting has served to consolidate the floating mass of facts which we have accumulated and to add support for the contention that one cultural influence is responsible for the earliest mining and smelting and washing of metals and the getting of precious stones and pearls.

In the consideration of these problems it is of crucial importance not to forget that the mining and working of metals had been carried on for several centuries around the Eastern Mediterranean before the knowledge of these arts burst the bounds of that region. Within the limits of the latter the spread of these practices occurred under circumstances very different to those that came

[39] "It is important to note . . . that the type of furnace which still survives in India among the hill tribes of the Ghats is closely analogous to the prehistoric furnace of the Danube, and of the Jura district in Europe. . . . . ." Gowland, *Journ. Roy. Anth. Inst.*, XLII., p. 279.

into operation in the Far West and the East. In the latter cases the new knowledge was carried abroad as part of a definite culture, which was built up by an artificial combination of practices within the area of the Eastern Mediterranean. The argument here deals essentially with the regions beyond its limits. The apparently contradictory state of affairs in Northern Italy and Switzerland—the absence of megalithic monuments which are invariably associated with ancient mines further west—is due, no doubt, to the fact that the circumstances under which elements of culture ultimately derived from Egypt were introduced there differed essentially from those which obtained in the west. They probably came into operation earlier and more indirectly.

All the evidence put forward here enables us to reach a generalisation which must have already become obvious. In all the cases quoted some very good reason can be assigned for the presence of the carriers of the megalithic culture in any given place—gold, pearls, tin, and so forth are known positively to have determined their presence in certain localities: all this is well known. But now we can sum the matter up quite simply.

The cause of the distribution of the megalithic culture beyond the area of the Eastern Mediterranean was the search for certain forms of material wealth.

Gold, tin, copper, pearls, precious stones, and so forth were eagerly sought after, and where they were discovered, there the megalithic influence soon made itself felt.

The search for wealth is the underlying factor in the distribution, and it seems to provide the motive for the wide-spread travellings of these people. To the Baltic they went for amber, to France for gold and tin, to Spain for many metals, to West Africa for gold and other things: these are some of their wanderings. But the

imagination is surely struck most forcibly by the thought of these Ancient Mariners sailing to India, then to the East Indian Archipelago, and thence right out across the Pacific by way of the Carolines, Solomons, New Hebrides, Fiji and Easter Island to the coast of America, there to discover immense stores of all kinds of wealth, gold, silver, pearls, and precious stones, and to settle down as kings and over-lords, using their immense cultural superiority to transform the indigenous cultures and to found there the civilisations which have long been the wonder and admiration of mankind.[40]

This wandering in the search for wealth is a remarkable thing, and it has been the great civilising factor: it is that which has caused the step from savagery upwards to have taken place in many parts of the earth. For good or evil, once it began, mankind was bound to gain in knowledge, experience and wealth. When the details are available it will be possible to make the picture complete. At present we have the bare outlines. But none the less the facts have grouped themselves so as to make the nature of the picture evident. They also enable us to state what appears to have been the most important form of wealth for which the megalithic people sought. It was gold. The search for that substance would seem to have attracted those for whom it had great value to immense

[40] The Greek colonisation of Spain was also determined by similar motives. "Qu'allaient faire les Grecs dans ces régions d'accès difficile? Si l'on cherche à répondre à cette question, on ne peut pas ne pas attribuer une signification à ce fait que les traditions qui parlent des plus anciens établissements grecs, les placent dans les régions métalifères; ansi la ville d'Ulysse est près des mines les plus riches en argent; parmi les colonisations du Nord-Ouest, Ocela (Ocelum de Ptolémée) se trouve près de Zamora, précisément dans un des centres principaux des gisements d'étain en filons et en alluvoins le long du Douro; c'est aux riverains de celui-ci que Stralon attribue des moeurs lacédémoniennes, et aux peuples de Nord-Ouest riche en mines d'étain et d'or les différents coutumes grecques que nous avons signalées.' (Siret, 19, p. 158.)

distances. A glance at the maps will at once show the truth of this remark. Ireland, Wales, Devon and Cornwall, France, Spain, Switzerland, Italy, Macedonia, Thrace, Troad, Lydia, Armenia, Nigeria, Arabia, Thibet, Assam and Chota Nagpur, are among the places where gold was washed in antiquity. This widespread search for gold is highly significant. It implies that gold had acquired a value as currency. Perhaps I may quote Mr. C. W. King on this subject. "Pliny," says he, "launches out into a set of reflections in his own quaint style, astonished as to what possible motives could have induced all mankind to make gold, wherever known, the first and chiefest representative of value. It was and is indeed a strange coincidence in the notions of races, however remote from or unconnected with one another, that must early have puzzled every observer."[41] And so on. According to the thesis here put forward the wide acceptance of gold as a standard would be the result of Egyptian influence. It would seem that gold came to have a standard of value in Egypt, and that it was the first form of currency. This would mark an event in the history of mankind of the first importance. With a commodity capable of universal barter, wealth could be stored up, and, where large quantities of it existed, there could civilisations be founded. The Egyptians had immense gold mines. De Launay tells us that "there were manifestly several great mining centres in Asia Minor five centuries before Christ, which are known to us through Herodotus" In Chaldea, he says also, "gold was present in lodes and sand." Indeed, "the earliest centres of gold mining were evidently in the zone of the most ancient civilisations, in Armenia, Chaldea, Asia Minor, and Egypt."[42] These coincidences cannot be

[41] *Op. cit.*, p. 93.
[42] *Op. cit.*, pp. 82, 84.

due to chance. It cannot be contended that in these places, in addition to Tuscany, with its immense gold washings in the Po Valley, and Thrace and Macedonia and the Troad, gold suddenly came to acquire a value as currency. It can only be that most of these civilisations sprang up on a gold basis. Since Egyptian civilisation dates back furthest, it would seem that the Chaldean civilisation and those of Asia Minor owe their existence, directly or indirectly, to Egypt.

In short the whole history of the influence of Egypt upon the rest of the world covers a period to be counted by thousands of years. Beginning perhaps with gold-washing colonies in Chaldea and Asia Minor, themselves destined to grow into mighty civilisations, and extending thence wherever gold and other desired things were found, this influence spread in a series of waves. The greatest of these, the tidal wave which threw up the cargo of customs and beliefs on the coasts of the remotest parts of the world, reached its phase of maximum intensity at the time when the Phœnicians, those apt pupils and amazing adventurers and traffickers, reached the summit of their activities.

Remarks on Mr. W. J. Perry's Communication.

By Professor G. Elliot Smith, M.A., M.D., F.R.S.

One of the most puzzling features of the geographical distribution of megalithic monuments hitherto has been the apparently haphazard way in which certain sites have been selected and others left by the builders of these curious stone structures. Mr. Perry has provided the explanation. The coincidence of the distribution of the monuments and the mines is far too exact to be due to mere chance. Ancient miners in search of metals or precious stones, or in other cases pearl-fishers, had in every case established camps to exploit these varied sources of wealth; and the megalithic monuments represent their tombs and temples.

That the chief exploiters of the Iberian (and probably also the Indian) mines in question were the Phœnicians can now be regarded as definitely established.[1] But it is not so obvious why the Phœnicians should have built monuments of the characteristically "megalithic" type. It is probable that they recruited for these special expeditions men who were expert gold-miners, in much the same way as in our own times one sometimes meets prospectors who have worked in turn at Ballarat, Coolgardie, the Transvaal and Klondyke.

There is a good deal of evidence to suggest that the Phœnicians may have recruited many of their miners from the Black Sea littoral, and especially from Colchis, the land of the Golden Fleece, and that these men built

[1] See L. Siret, *op. cit. supra*; and my article "The Influence of Ancient Egyptian Civilization in the East and in America" in the forthcoming (January) Bulletin of the John Rylands Library.

megalithic monuments in mining camps, as far apart as Spain and India, in much the same way as they were accustomed to do in their own country in the Caucasus.

These Colchian dolmens were certainly inspired, directly or indirectly, by Egyptian models, such as the mastabas.

Most modern scholars are inclined to regard the account of the Colchians given by Herodotus as a mere traveller's tale devoid of any real justification. But there is so much archæologicai evidence in support of his statements, and moreover he gives such precise and cogent reasons for them, that I am convinced there is an element of truth in his contention. "For the Colchians were evidently Egyptians, and I say this having myself observed it before I heard it from others; and as it was a matter of interest to me I inquired of both people, and the Colchians had more recollection of the Egyptians than the Egyptians of the Colchians; yet the Egyptians said they thought the Colchians were descended from the army of Sesostris; and I formed my conjecture, not only because they were swarthy and curly-headed, for this amounts to nothing, because others are so likewise, but chiefly from the following circumstances: because the Colchians, Egyptians, and Ethiopians, are the only nations of the world who, from the first, have practised circumcision" (Euterpe, Book II., Sect. 104, Cary's translation) . . . "I will now mention another fact respecting the Colchians, how they resemble the Egyptians. They alone and the Egyptians manufacture linen in the same manner; and the whole way of living, and the language, are similar in both nations" (*ibid.*, Sect. 115).

This presumably means that some community, amongst whom the Egyptian funerary practices of the

Old Kingdom had survived, carried their customs to Colchis, perhaps as sailors manning the ships of Phœnicians or as soldiers in the army of an Egyptian king, which the vague designation "Sesostris" of the Greek historian suggests.

The reference to the swarthiness and curly hair of the Colchians suggests an Ethiopian origin. In this connexion it is perhaps significant that in the story told by Herodotus "Sesostris" is said to have visited the Black Sea in the course of an expedition which began in the Red Sea. It is perhaps possible that the original miners of Colchis may have come from the Egyptian mines in the Eastern Desert. In the account of the burial customs of the Scythians (of the Black Sea littoral) given by Herodotus, not only were Egyptian methods of mummification adopted (see "The Migrations of Early Culture," p. 66), but also the practice of killing wives and attendants, which I regard as a Sudanese addition to the Egyptian burial customs (*op. cit.*, p. 56).

In the account of his excavations in the Kuban district of Southern Russia, M. de Majewski describes the finding of a curious clay model of a pile-dwelling, which he refers "to a well-defined phase of pre-Mycenean culture at the latter part of the Neolithic."[2]

After much searching for analogous dwellings elsewhere, M. de Majewski ultimately found what he wanted in the bas-reliefs at Dêr el-Bahri of Queen Hatshepsut's expedition to Punt, and came to the conclusion that "il paraît donc que quelque part, sur les bords de la Mer Rouge, ou sur les rives du Nil supérieur, on construisait les habitations humaines de la même façon que sur les bords de la Mer Noire" (*op. cit.*, p. 233).

[2] "Habitation humaine (enclos) sur pilotis de la fin du néolithique," *Bull. Soc. d'Anthrop. de Paris*, April 3, 1913, p. 229.

It is also not without significance that the same expedition was responsible for introducing into Egypt, at least for the sacred purposes of Queen Hatshepsut's Theban temple, the "myrrh-terraces of Punt" (Southern Arabia). This is the earliest reference to terrace-cultivation (about 1500 B.C.).

On the present occasion it is not my intention to follow up the multitude of complex problems suggested by these references. They have, however, a double bearing on the present discussion, in that they afford a certain amount of *prima facie* evidence in support of the contentions, (*a*) that some time after the 16th century B.C., Ethiopian gold-miners may possibly have begun to work in the Colchian area, and that the type of dolmen found there may have been inspired from Egypt in that way; and (*b*) that Egyptian elements of culture may have reached the Danubian area by way of the Black Sea.

But whether this be so or not the megalithic monuments both of Spain and India represent the degraded survivals of monuments originally inspired by the methods of tomb-construction that prevailed in Egypt many centuries before, in the remote Pyramid Age. The crews of the Phœnician ships, or the skilled miners who exploited the wealth of the distant settlements, were responsible for distributing these customs far and wide.

The Black Sea littoral provides a most important series of megalithic monuments ranging from Bulgaria to the Caucasus, in every case in association with ancient mining settlements. In fact, Mr. Perry might have referred to this area in the same way as South-Western Europe and India have been used to demonstrate his contention.

In his statements concerning the pile-dwellings and Terramara of Switzerland and Italy, he has touched upon

a problem of extreme difficulty and complexity. To have omitted specific reference to these sites of early mining would have laid him open to the charge of shirking discussion of a case which seems to go against his generalisation: for dolmens such as occur in association with early mines in the East and West are lacking in the Terramara area.[3]

Mr. T. E. Peet tells us[4] that the "internal evidence for the identification of the lake-dwelling and *terramara* people with an invading race from Central Europe is overwhelming." Whether this is so or not, there can be no doubt that along with such un-Egyptian burial customs as cremation, and many other northern practices, they combined others which were certainly derived, directly or indirectly, from Egypt and the South. The suggestion already made in a preceding paragraph may possibly explain how certain Egyptian practices may have reached Italy and Switzerland by way of the Danube from the Black Sea.

There can be no doubt, however, that the mining settlements in northern Italy were established several centuries before, and under circumstances vastly different from those which, in comparatively recent times, the Phœnicians were responsible for planting in the Iberian peninsula. But once the investigator enters the domain of the old civilizations the conditions become so complex that it is no longer possible to rely upon those clear indications of the definite source of cultural inspiration which can be made use of beyond the limits of that

[3] A dolmen, however, has been recorded in association with the lake-dwellings at Auvernier, near Lake Neufchatel (see De Nadaillac's "Moeurs et Monuments des Peuples Prehistoriques," Paris, 1888, p. 291 and Fig. 106,—in which he refers to Gross, "Les Proto-Helvetes," and Morel-Fatis, "Sepultures des populations lacustres de Chamblandes," as his authorities).

[4] "The Stone and Bronze Ages in Italy and Sicily," p. 510.

area. For the Phœnicians collected a series of customs from every part of the Eastern Mediterranean, irrespective of whether they were Egyptian, Babylonian, or Mycenean in origin ; and when they distributed them among the more distant uncultured lands, they became sure indications of *Phœnician* influence Once, however, the investigator enters the area of these old civilisations, where the various elements of the culture-complex originated, these no longer can be used as tokens of Phœnician influence, for all the circumstances of the case are then altered. Northern Italy was probably influenced by these older civilizations without the intermediation of the Phœnicians.

There is one other point in Mr. Perry's communication which calls for comment—the important rôle played by pearl-shell in leading the distributors of the megalithic culture to the East. In her interesting memoir on the transmission of the use of the Purpura shell-fish from the Eastern Mediterranean to Mexico, Mrs. Zelia Nuttall[5] emphasised the intimate relationship that existed between the use of purple for dyeing, conch-shell trumpets and a special appreciation of pearls. Professor R. C. Bosanquet has called attention[6] to the fact that the use of purple, the discovery of which had been credited to the Phœnicians, was probably due to the Minoans. A collection of crushed shells of *Murex trunculus* discovered by him in Crete are referred to a date at least as early as 1600 B.C.

Moreover, the conch-shell was used as a trumpet in Crete, and is said to have been "a regular accompaniment of Minoan religious worship."[7]

[5] A Curious Survival in Mexico of the Purpura Shell-fish for Dyeing," *Putnam Anniversary Volume*, 1909.

[6] "An Early Purple-Fishery," *Report Brit. Assoc.*, 1903, p. 817.

[7] H. H. Hall, "Ægean Archæology, 1914, p. 155.

When pearls first were sought after is not known: but the intimate association of a special appreciation of pearls with the use of purple and of the conch-shell suggests that the persistent search for these other shells may also have been responsible for the development of the fashion for the pearl-shell.

The Phœnicians no doubt acquired from the Mycenean peoples their knowledge of the making of purple and the custom of using the conch-shell trumpet. In course of time, as the demand for these shell-fish increased and the Mediterranean supply became inadequate, it is probable that the Phœnicians began to search the Red Sea for them: this may have been responsible for the inauguration of the definite trade in pearls and pearl-shell, which was destined to be the primary incentive which led the Phœnicians further and further to the East, until eventually they themselves, or some peculiarly apt pupils of theirs, were led right across the Pacific to the pearl-beds of the American Coast, the Antilles and the Mississipi. One of the factors in developing the special appreciation of the pearl-shell may have been an outcome of the use of the conch-shell in religious ceremonies in Crete. For it is known that when the use of the conch-trumpet was introduced into India, perhaps in the seventh century B.C., such importance was attached to its association with temple worship that special sanctity became associated with the shell itself.[8] A great variety of objects were made from the "chank," to which particular religious and magical value was attached; and the cult of white shells spread far and wide in the Far East, Oceania and America.

In India the geographical distribution of megalithic

[8] James Hornell, "The Sacred Chank of India," Madras Fisheries Bureau, Bulletin No. 7, Madras, 1914—See especially Chapter III.

monuments also represents that of the localities in which the "chank" is commonly used, even in modern times.

[Since this was written, Mr. J. Wilfrid Jackson has called my attention to the important evidence relating to the use of pearl-shell, the exploitation of purple, and the importation of Red Sea cowries, in Ireland and elsewhere in the British Islands (Edward Collier and Robert Standen, *Journ. of Conchology*, April, 1896, pp. 188 and 189: also J. W. Jackson, same *Journal*, April 1st, 1912). For the evidence of the use of purple in Gibraltar, see Duckworth, *Journ. Roy. Anthr. Inst.*, 1911, p. 363; and in New Zealand, see Colenso, *Trans. N. Zealand Inst.*, 1881, p. 57. The importance of this evidence in further corroboration of the identity of the motives and the methods of the culture-distributors who wandered respectively East and West from the Eastern Mediterranean is obvious. I hope that Mr. Robert Standen and Mr. Wilfrid Jackson will undertake the interesting task of following up these clues afforded by shells and present the results to the Society.]

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II. Notes on some Palæozoic Fishes.

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(Read October 19th, 1915. Received for publication October 25th, 1915.)

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February 7th, 1916.

During the last few years the collection of fossil fishes in the Manchester Museum has increased very rapidly by gift, purchase and exchange, until it is now one of marked importance, rich in specimens of morphological interest. It is our purpose in this paper to describe some of these of Palæozoic age belonging to the Crossopterygian and Dipnoan orders. The work forms part of an investigation into the origin of the Amphibia on which one of us has been long engaged. We intend to give as accurate and as full an account as possible of certain types and briefly to discuss their inter-relationships and certain points of morphological interest.

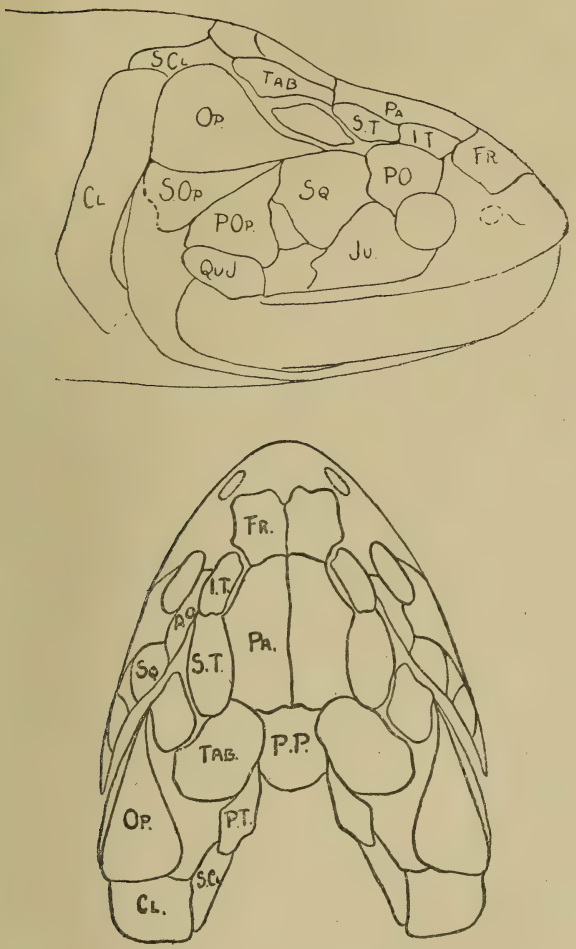
Holoptychius flemingii, Ag.

The structure of the small species of *Holoptychius* which occurs so abundantly in the yellow sandstones of the upper Old Red Sandstone of Dura Den in Fifeshire has been described by Agassiz and Huxley.

Dr. Traquair in 1896 published a restoration of the whole fish and E. S. Goodrich in 1909 an original restoration of the head. These works have made us acquainted with the general structure of the animal, its body form, squamation, and the general external appearance of its fins, being well understood. Investigations of Owen have made us acquainted with the structure of its teeth, and Rohon, working on Russian materials belonging to the same genus has added to our knowledge of its skull.

Despite all this, however, our detailed knowledge of the skull structure remains very small. The head of the restored figure by Traquair is by far the most accurate contribution to a knowledge of its cranial osteology, but even this is in some ways inaccurate.

Our study is founded on the heads of seven individuals



Text-fig. 1.—*Holoptychius flemingii*, Ag. Restoration of head (dorsal and right lateral aspects). CL., Clavicle; FR., Frontal; I.T., "Intertemporal"; JU., Jugal; OP., Operculum; PA., Parietal; P.O., Post-orbital; P.OP., Pre-operculum; P.P., Post-parietal; P.T., Post-temporal; QU.J., Quadrato-jugal; S.CL., Supra-clavicle; SQ., Squamosal; S.T., Supra-temporal; S.OP., Sub-operculum; TAB., Tabular. Whenever possible, bones are referred to under the names by which they are known in Amphibia, but the nomenclature of the clavicular apparatus is that of fish.

from the classical locality, in the Manchester Museum. Many of these are well preserved and although none is complete, they supplement one another so as to give clear information about the whole of the external surface of the skull except in the premaxillary and narial region.

As these skulls are not seriously crushed, we have considerable certainty of their original shape. *Holoptychius* had a body nearly circular in section at the pectoral girdle. The head is very short, the orbits far forward and mainly laterally directed. The dorsal profile does not form a uniform curve but rises somewhat abruptly a short distance behind the orbits, the anterior part of the head being in consequence dorso-ventrally flattened.

The general structure will be best understood from the restorations (*Fig.* 1) which have been drawn with great care and are projections one from the other. At the extreme back of the skull, in the mid-dorsal line, is a large bone which corresponds with the two post-parietals which are so constant a feature of early Amphibian and Reptilian skulls. We propose to call this bone the post-parietal. The post-parietal is bounded on each side and is in fact overlapped to a large extent by the tabulars which are large dermal bones ornamented with a slightly impressed sculpture of ridges and grooves. In front of this transverse row of three bones lie the parietals, which meet one another in median suture, and together form a large six-sided area on the top of the head. Each articulates with five other bones in addition to its fellow. The lateral margin from the tabular forward, articulates by a rather close suture with a small oval bone which we intend to call the "supratemporal" because it is obviously homologous with the bone which has commonly borne that name in Stegocephalia."[1] In advance of the "supratemporal"

is another bone much less closely connected with the parietal, which we shall call the "intertemporal"[1] The anterior end of each parietal is very loosely connected with the frontal, a small square bone having a median suture with its fellow from which it is not separated by a pineal foramen, and playing no part in the margin of the orbit. In front, the frontals are connected with the shield which covers the anterior end of the snout, but of whose structure we are ignorant.

The orbit lies below the "intertemporal" and frontal, separated from them by two bones, the posterior of which articulates with the whole lateral margin of the "intertemporal" and to some extent with that of the "supratemporal." This bone articulates behind with a large element on the side of the face, whose upper margin is separated from the posterior part of the "supratemporal" and the tabular by a space to some extent filled by a bone which will be described in connection with the opercular apparatus. We propose to call this large cheek plate the squamosal. The curve of its upper margin is continued backward by that of another large triangular element which articulates with it in a short suture, below which its anterior border is separated from the posterior border of the squamosal by a small triangular bone which we do not propose to name. The large element is obviously pre-operculum. The lower margin of the pre-operculum overlaps a small quadrate element the quadrato-jugal. The lower and posterior quadrant of the margin of the orbit is formed by a bone whose dorsal border articulates with the post-orbital and squamosal, and whose lower edge is covered by the maxilla. As it

[1] We are aware that the use of this name is strongly to be deprecated, but use it here in order to avoid the introduction of a new term because the whole question is shortly to be considered by a committee of the American Palæontological Society.

is preserved to us this bone does not reach back to the pre-operculum and the quadrato-jugal but leaves a small irregular opening in the long cheek, which may perhaps, but very improbably, be original, but is more likely to have been closed by a separate element of which indeed some traces seem to be visible in a single specimen. The maxilla is a long somewhat shallow bone lying entirely in the skin and extending from the premaxilla to the quadrato-jugal. It overlaps all bones which lie above it, and its lower margin is tooth-bearing. The anterior border of the orbit is surrounded by a bone or bones of which we can say nothing.

Fitting into the gap between the squamosal and tabular is a small quadrate bone whose lower and posterior margin is connected with the upper border of the large operculum. This element fits closely up to the tabular and its posterior edge is rounded. It overlaps the sub-operculum below it, whose anterior border fits the pre-operculum. The remainder of the opercular apparatus is not well shown in the Manchester specimens, but the sub-operculum supports the posterior of the lateral gulars, which themselves articulate with the paired principal gulars.

Articulated with the inner sides of the tabulars are distinct post-temporals, thin dermal bones with a great resemblance to scales. These support slender triangular supra-clavicles which themselves pass under the upper ends of the powerful clavicles, great sickle-shaped bones with a wide exposure on the whole flank of the fish behind the opercular apparatus. The lower ends of these bones overlap the upper ends of the infra-clavicles which are themselves triangular bones on the ventral surface of the fish filling up the notch between the posterior margins of the principal gulars. From the outer corner of each

arises a special process with which the clavicle articulates.[2]

Our observations have served to convince us of the great general accuracy of Dr. Traquair's restoration but one well preserved fish gives evidence of the occurrence of a large scale covered lobe in the second dorsal, and a similar but a smaller lobe in the anal fin. The external structure of these fins is in fact quite similar to that of the typically "Crossopterygian" pelvic limb.

Glyptolepis paucidens, Ag.

The Manchester material does not permit us to add anything to our knowledge of the skull structure of this type, but a small slab collected by one of us at the famous quarry of Achanarras shows numbers of well preserved scales of *Glyptolepis paucidens* associated with the somewhat imperfect impression of the caudal part of the vertebral column. This specimen is scarcely in a condition to afford detailed information but shows quite conclusively that the vertebral column of *Glyptolepis* is of a temnospondylous nature. At the anterior end the elements are naturally arranged and seen to show neural arches attached to pleurocentra which extend about half the height of the column, the condition being apparently rhachitomous. Posteriorly the neural arches with their attached pleurocentra have been dragged away from the series of hypocentra so as to suggest that the condition is nearly embolomerous. In both regions the ossifications appear to be paired and are slender segments of rings. Despite its imperfection this specimen is of considerable

[2] Throughout this paper the terms for the clavicular apparatus are those ordinarily employed by students of fish and are not to be interpreted as implying the acceptance of any view of their homology with those of Tetrapods.

importance because it is the only fragment of a Palæozoic fish showing a vertebral column of this type, and it is certain that the Amphibia arose from fish with a temnospondylous vertebral column of some form.

Glyptopomus kinnairdi, Huxley.

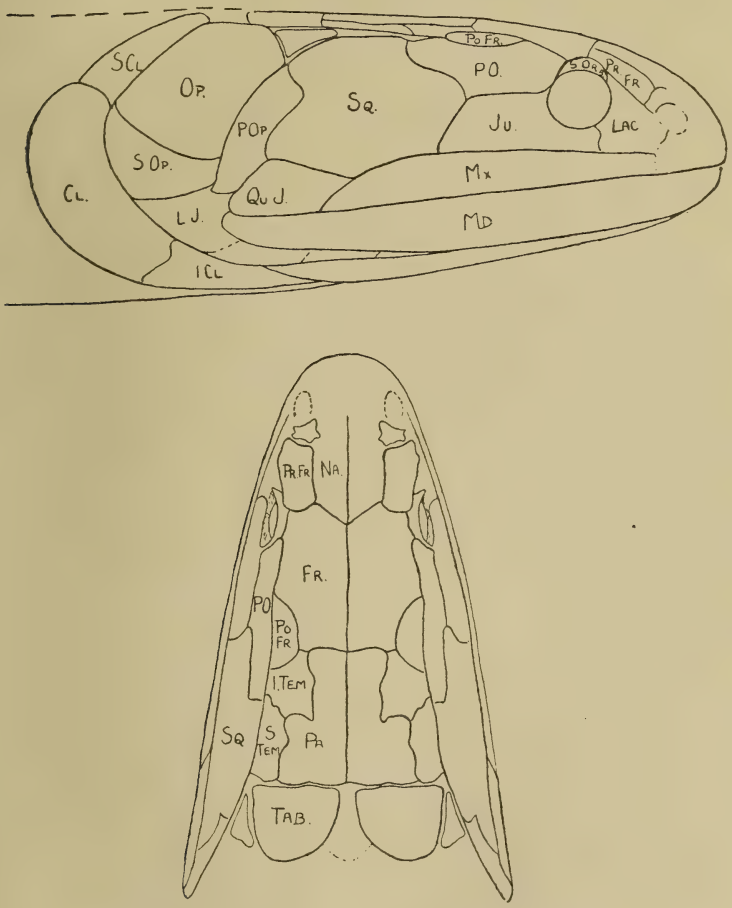
The structure of this fish has been described by Huxley in a classical paper and Goodrich has published a new restoration of the head and of the fish.

The heads of four specimens on a single slab obtained in the recent excavations carried on by a committee of the British Association at Dura Den, allow us to produce a new and, as we hope, accurate restoration of this fish. They are excellently preserved and well exposed.[3]

Glyptopomus is a remarkably elongated fish, and in consequence its whole head and the bones composing it are long and slender when compared with the corresponding parts of *Holoptychius*. The orbit is far forward and somewhat small, whilst the gape is of great length. The post-parietal and tabulars resemble those of *Holoptychius*, especially in the very small exposure of the median element. The parietals, and the "supratemporals" and "intertemporals" are closely articulated so as to form one nearly flat plate. Loosely articulated with this plate by a joint which was apparently flexible during life, are the very large frontals. These appear to meet one another in the middle line throughout their length, there being no pineal foramen, although this opening has been reported by Huxley and Goodrich. The nasals are

[3] Only one of these heads is attached to a well-preserved body, the scales of which are badly shewn. It is conceivable that they really belong to "*Gyroptychius heddlei*" Traq. and not to *Glyptopomus*, although the complete individual agrees well enough with one of Huxley's figures of that fish.

paired and distinct, apparently not fused with the pre-maxillae and other bones to form a shield over the snout. Articulating with the posterior part of the lateral border of the frontal and with the "intertemporal" is a small



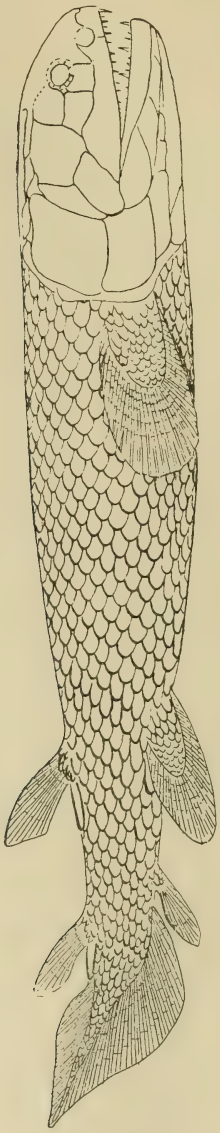
Text-fig. 2.—*Glyptopomus kinnairdi* (Huxley). Restorations of the dorsal and right lateral aspects of the skull. ×⅔. Reference letters as in *Fig.* 1 with :—I.Cl., Interclavicle ; Lac., Lachrymal ; Md., Mandible ; Mx., Maxilla ; Na., Nasal ; Po.Fr., Post-frontal ; Pr.Fr., Pre-frontal ; S.Orb., Supra-orbital.

oval bone not represented in *Holoptychius*. The post-orbital articulates with this bone and with the frontal, which is almost excluded from the orbital margin by a special small supra-orbital bone and by the jugal. The squamosal is a very large element articulating with the post-orbital and jugal and having its upper margin very free although for some distance it follows the "supra-temporal." The pre-operculum has a narrow exposure and its posterior edge continues the curve of the upper border of the squamosal. The quadrato-jugal is a quadrilateral bone of a fair size articulated above with the pre-operculum and the squamosal. The circumorbital bones in addition to the post-orbital and jugal include a small crescent-shaped supra-orbital ossicle, a large lachrymal which articulates both with the jugal and with the supra-orbital ossicle, and a bone which is apparently a pre-frontal articulates with the frontal, nasal, lachrymal and the supra-orbital ossicle, and in front ends in contact with a small bone whose anterior margin is a rounded notch which has apparently formed the posterior border of the external nares. The maxilla is the usual long narrow slip forming most of the oral margin and overlapping all bones which lie above or behind it. A small bone exactly similar to one which we have already described in *Holoptychius* fills up the gap between the squamosal and the tabular. It is immediately succeeded by a large pentangular operculum whose lower border overlaps the narrow sub-operculum which itself is succeeded by the first of the lateral gulars. We have been unable to observe any distinct post-temporal, but one may be present. The supra-clavicle is a large flat bone whose lower and posterior end passes behind the top of the very massive clavicle. The infra-clavicle is an even larger bone of indescribable shape. We have nothing to

add to the account of the gular apparatus given by Huxley. One skull is so preserved as to show the dorsal surface of the palate. As exhibited it consists of a broad dorsally channelled parasphenoid whose lateral surfaces are in contact apparently by specialised processes with the pterygoids at about the middle of their length. Where it is in contact with the parasphenoid the pterygoid consists of a nearly vertically placed sheet of bone which is concave outwardly. As it is traced forwards this concave shell becomes converted into a nearly horizontally placed flange whose inner margin is in contact or nearly in contact with its fellow in the middle line. Behind the articulation with the parasphenoid, the vertically placed shell is continued, its upper margin tending to be directed outwards until at the extreme back of the skull at the level of the quadrato-jugal the bone terminates in an outwardly turned process which is in contact with an ill-preserved mass representing the quadrate. The quadrato-jugal lies to the outer side of this mass. The lateral margins of the bone in the anterior part are in contact with two bones, the posterior, the ectopterygoid being a flat bone with a row of teeth near its outer edge, the anterior the palatine, an exactly similar bone except for the occurrence of a definite foramen whose border is smooth and turned dorsally. The bone terminates just in advance of this opening. Further forward lie the prevomers, not well preserved, each of which is, however, shown to bear a large tooth and to articulate with the anterior ends of the pterygoids and palatines.

The remainder of the fish seems to agree well with the restorations published by Huxley and Goodrich, although the pectoral fin is not quite so acutely lobate as it is represented in the latter's figure. This fin is represented in *Pl. I., Fig.* 4, from which its structure will be obvious.

Rhizodopsis sauroides. (Williamson.)



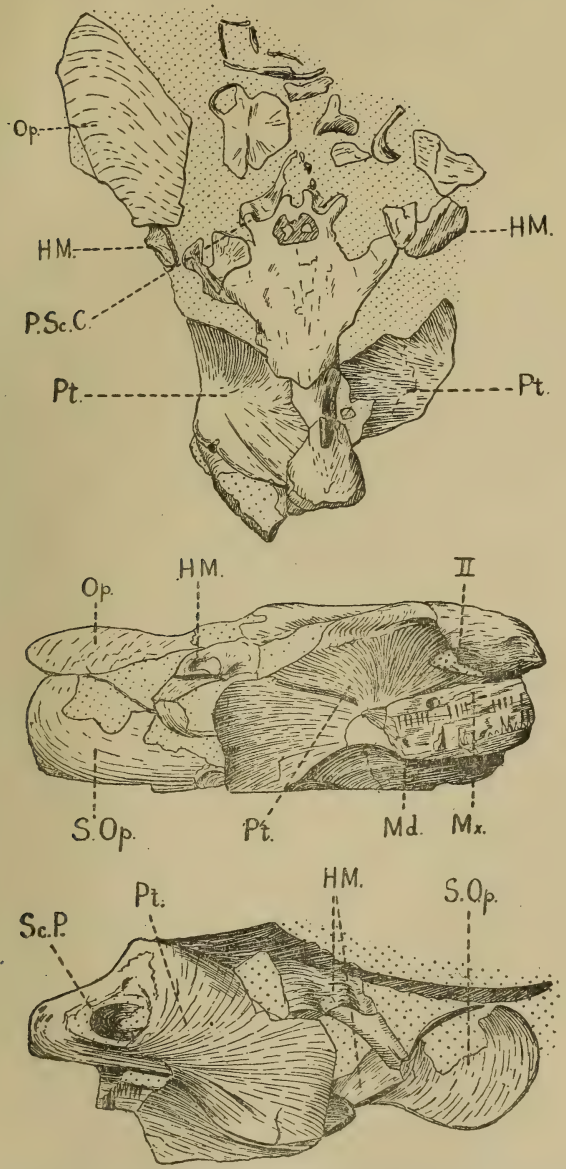
Text-fig. 3.—*Rhizodopsis sauroides* (Williamson). Restoration of whole fish. Natural size of a small specimen.

Rhizodopsis sauroides is of interest for many reasons. In his original paper Williamson described it as "an extinct salmon" on superficial resemblance of squamation. But even in his earliest paper he gave an account of a somewhat distorted fish showing all the fins. This specimen was the first nearly complete fish to be found in the Lancashire coal measures or indeed we believe in the coal measures of England. It is now in the Manchester Museum and has served us for a study of the median fins. Our knowledge of the fish however really depends on a classical description which Dr. Traquair gave in 1881, the first thorough study of the cranial osteology of a Crossopterygian fish ever published in England. The materials which we have used consist of eight specimens from the Knowles Ironstone of Fenton, Staffordshire, and numerous specimens in shale, two of which, one being Williamson's original, are important for the study of the median fins. An entirely independent restoration of the head made from this material agrees with that given so long ago by Dr. Traquair in all important features but differs slightly in the proportions of certain bones, and in the general shape. In addition we have observed a small process rising from the anterior end of the maxilla, whose anterior border forms a rounded margin which can only be that of an external nostril. As this process is not present in all specimens it is in all probability really a separate bone. In addition we have observed the presence of a series of well interlocked sclerotic plates in the eyeball bearing a very considerable resemblance to those which are so familiar in *Ichthyosaurus*. We have observed considerable difference in proportion of bones in fish of different sizes.

One remarkable specimen in the Knowles Ironstone shows a good deal of the cartilaginous portions of the

head, largely as a cast in gypsum of cavities left in the ironstone by the decay of the cartilage. This specimen shows us that there is a large cartilaginous cranium lying to a considerable extent below the parietals but extending far forward into the ethmoidal region. So incompletely is it exposed that our account of it can only be very slight. As exhibited it shows at its extreme posterior end a narrow dorsal surface over the cerebellar region which suddenly expands to form a pair of ridges presumably housing the posterior vertical semicircular canals. Forward of this region the upper surface is essentially flat and is closely applied to the under surfaces of the parietals and "supratemporals." The lateral borders are produced in powerful and somewhat lengthy processes, with the outer ends of which the hyomandibulars articulate. From here the brain case rapidly narrows, until between the orbits it is far higher than wide. It then expands again slightly in the ethmoidal region.

The palate is incompletely but satisfactorily exposed in this specimen. The large pterygoidal element resembles in its structure that which we have already described in *Glyptopomus*, but the vertical part of the bone which in that form is shown to lie behind the articulation with the parasphenoid here rises to the top of the skull, so as nearly or quite to come into contact with the cranial roof. The posterior end of the bone is clearly shown to be deflected outwards to surround the quadrate, the extreme tip of which is visible and whose position is certain from the known structure of the articular of the lower jaw, which is still in natural articulation with it. The specimen leaves it uncertain whether the ectopterygoid and palatine are really separate bones or are fused as in *Megalichthys*. The specimen rather suggests that the ectopterygoid is fused whilst the narrow palatine retains



Text-fig. 4.—*Rhizodopsis sauroides* (Williamson). Dorsal and right lateral aspects of a head showing the dorsal surface of the pterygoids and palatines, of the chondrocranium and the hyomandibulars. × 1⅓. HM., Hyomandibular; P.Sc.C., ridge of the chondrocranium over the posterior vertical semicircular canal; Pt., Pterygoid; II., foramen for the optic nerve; Sc.P., Sclerotic plates.

its individuality. In any case, these bones, instead of the row of small teeth which they support in *Glyptopomus*, carry powerful fangs, three of which are visible in the specimen. This specimen is further of importance because it shows the hyomandibular. This bone, although of quite large size, seems to be extremely feebly ossified, the bone forming a mere skin. It articulates with the special process of the otic region of the chondrocranium which we have described, passes backwards behind the posterior border of the pterygoid, and then is either suddenly bent at right angles so that its lower half is directed forwards, or terminates, the lower half being a separate bone. In any case, the lower termination of this bone, whatever be its nature, rests on the pterygoid, where it sheaths the quadrate just above its lower edge. This specimen on both sides exhibits a foramen of medium size, which pierces the hyomandibular just below its head.

Two specimens give evidence of the presence of an elaborate series of hyoid arches apparently entirely cartilaginous in structure, but do not allow us to give any description.

In *Rhizodopsis* we have been unable to see any specialised post-temporal but the supra-clavicle is a large bone of ovate shape whose lower and hinder end passes on to the visceral surface of the clavicle.

The clavicle is a very large bone consisting of two rami one of which stands vertically being exposed on the flank of the fish behind the operculum and sub-operculum, whilst the other passes forward and downwards behind the last lateral gular until it is overlapped by the small infra-clavicle. There is some evidence of a feeble ossification in the cartilaginous shoulder girdle, and the proximal element of the fin is well, though superficially ossified.

The Knowles Ironstone specimens being compara-

tively uncrushed, serve excellently for the study of the trunk and of the paired fins, but none of those at our disposal show the median fins. The pectoral fins were well illustrated by J. Ward, and all the specimens which we have seen agree with that which he has figured in having pectoral fins closely applied to the ventral surface of the body and inserted at the junction of the two rami of the clavicle. They are short lobate fins, the scaled area being rounded and about half the length of the fin. The pelvic fins stand free from the body vertically in the matrix. They also, are short Crossopterygian fins, presenting in themselves no special features, but each accompanied by a special free scale or spine arising from the fin root between the fin and the body and passing backward. This spine is not part of the general squamation, and may perhaps be an intromittent organ analogous to the Elasmobranch clasper, but it is present in all specimens which might be expected to show it, which have come under our examination. The anus lies between the pelvic fins, its position being indicated by a slight modification of the squamation. (*Pl. I., Fig.* 2.)

Our account of the median fins is founded mainly on Williamson's small original specimen. The relative size of this individual has been determined from its well exposed operculum, but the known variation in proportion of this bone suggests that the median fins shown in our restoration are not necessarily of appropriate size, although they cannot be greatly in error. Their structure will be best understood from the figures, but attention may be called to the occurrence of an elongated ridge scale behind each dorsal.

Individuals of *Rhizodopsis sauroides* differ very considerably in size, our smallest fish having been about fifteen centimetres long, and our largest nearly a metre.

They seem to show some differences in squamation, two large individuals having nearly rhomboidal scales with a definite chevron pattern of sharply marked ridges, whilst the smaller individuals have more rounded and much less definitely ornamented scales.

Gyroptychius microlepidotus. (Ag.).

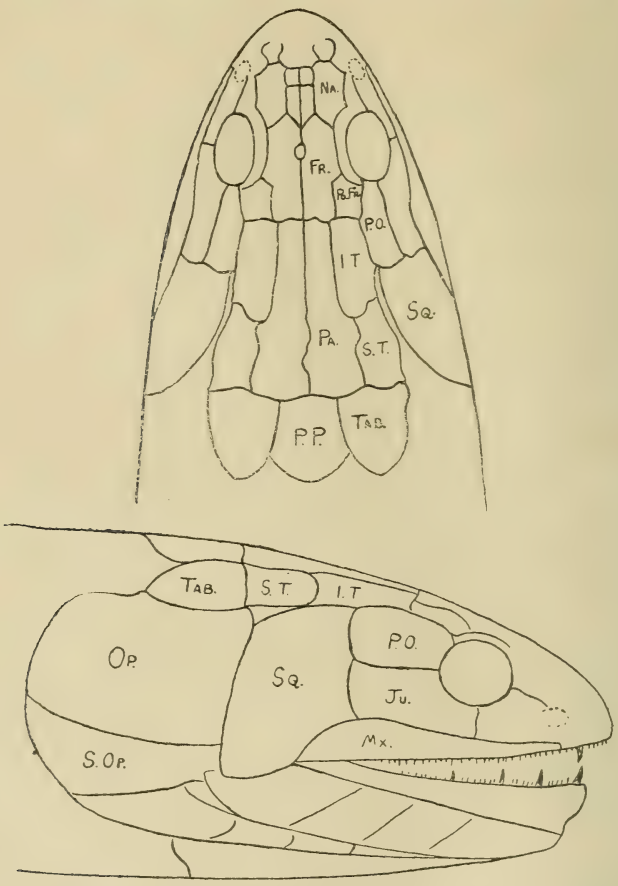
Three well preserved specimens of *Gyroptychius*, one from Tynet Burn, the others from the Enstabile Quarry in the parish of Sandwick in Orkney, allow us to add to the existing knowledge of this fish. The structure of the head seems to be, as it has already been represented by Traquair, nearly identical with that of *Osteolepis*, there being a single large cheek plate corresponding with the squamosal, pre-operculum, and quadrato-jugal of *Rhizodopsis*. The pectoral fin differs from that shown in Dr. Traquair's figure in its considerably greater size and in the large somewhat bluntly pointed scaly lobe which bears a great resemblance to that of *Glyptopomus* and differs markedly from the broad bluntly terminated lobe of the pectoral in *Rhizodopsis*. The specimen L. 8432 from Tynet shows very clearly the presence of a pair of elongated elements, thick semi-cylindrical scales, associated with the pelvic fins. These agree precisely with the similar bones we have described in *Rhizodopsis*. The extreme attenuation of the scaly caudal lobe is very well shown in this fish, the whole of whose caudal extremity considerably resembles that of *Rhizodopsis*. One of the Orkney specimens, L. 8431, shows the ornamentation of the scales very beautifully. They are quite rhomboidal scarcely more rounded than in *Osteolepis* and ornamented with V shaped ridges directed backwards on the exposed area of the scale.

Tristichopterus alatus, Eg.

The fine series of *Tristichopterus alatus* collected by one of the authors at the Deerness Quarry, on the mainland of Orkney, shows some features not displayed in those which Egerton and Traquair figured. One individual, No. L. 8429, a very large fish dorso-ventrally crushed and viewed from the ventral surface, has had the cheek plates of the left side freed from the top of the skull, and turned outwards on the maxilla as an axis. They are now represented by the beautifully sharp impressions of their visceral surface. This shows quite clearly that, in addition to the large cheek plate described by Traquair as a pre-operculum, there are present a real pre-operculum and a small quadrato-jugal. The pre-operculum is of interest because it shows a ridge on the inner surface, which no doubt gave support to the hyomandibular. Except for the much larger size of the squamosal, the cheek region much resembles that of *Rhizodopsis*. Another specimen shows the endoskeletal supports of all the fins except the first dorsal. These agree very closely with those already described by Egerton and Traquair and very strikingly with those which are well known in *Eusthenopteron foordi*. A third specimen is remarkable for the beauty of preservation of the fins of the posterior half of the body. It shows that all the median fins and the pelvics are far larger than they are represented in Traquair's familiar restoration, the second dorsal and anal reaching to a point half-way between the origin of the caudal and its termination. This specimen also shows that the dorsal and ventral margins are produced in a way quite similar to that which characterises *Eusthenopteron*.

Osteolepis macrolepidotus, Ag.

The structure of *Osteolepis* is so familiar from the work of Hugh Miller, Pander, and Traquair that we



Text-fig. 5.—*Osteolepis macrolepidotus*, Ag. Restorations of the dorsal and right lateral aspects of the skull. × 2. Reference letters as before.

cannot expect to add appreciably to our knowledge of the fish, but we give here restorations of the dorsal and lateral aspects of the head made from Orkney specimens, in the hope that they may be of use, not only to readers

of this paper, but to other workers, as no modern restored drawings of an Osteolepid have been published. Our figure represents the most complicated arrangement of bones in the ethmoidal region which we have met with, other specimens showing a reduction in the number of elements obviously due to fusion. These bones, whatever their number, seem to be symmetrically placed.

In the small specimens from the Thurso Beds in Caithness belonging to *Osteolepis microlepidotus*, Pander, the whole fronto-ethmoidal region is fused into a solid shield showing only very slight traces of sutures although its shape is similar to that of the older specimens of *Osteolepis macrolepidotus* described above.

One specimen on slab No. L. 8425 shows very clearly that the enlarged ridge scales behind the dorsal fins really form part of the general body squamation.

The fact that it is still unfortunately impossible to recognise any distinct lines of descent even of the broadest kind in Palæozoic Crossopterygians renders their discussion a matter of considerable difficulty, and its results of an unsatisfactory nature. The figures and descriptions in this paper will serve to substantiate the general belief in the close relationship of all the animals which Smith-Woodward included in his sub-order. Rhipidistia, but they show that along with this general similarity in structure goes a far larger variability in detailed skull structure than has previously been suspected. We have been able to show the existence of several undescribed bones in the heads of *Holoptychius* and *Glyptopomus* and the problem now arises whether these fish with a very complex skull have arisen from types like *Osteolepis* with a simple one or vice versa. In Tetrapods it is a general rule that evolutionary change has led to a

reduction in the number of elements in the head. *Seymouria*, undoubtedly the most primitive of known Reptiles, has in its "intertemporals" bones which occur in no other reptiles, and all the later reptiles, birds, and mammals show the gradual loss of elements, which seems to have taken place, in the majority of cases at any rate, by a gradual reduction in size, followed by disappearance, and not by a fusion of neighbouring bones. One would expect that in fish also reduction of number of parts would be a feature in evolution and that it would be accompanied by the actual disappearance of bones and not by their fusion with neighbouring elements. From the restorations given in this paper it is perhaps possible to gain some idea of the truth of this statement, which may perhaps be done most easily by comparing *Holoptychius* with *Glyptopomus*. The general homologies of the bones are quite clear. Two small bones, the supra-orbital ossicle and that lying between the post-orbital and the frontal, which occur in *Glyptopomus* are not found in *Holoptychius* or indeed in any other Palæozoic fish. The interesting region however is that which lies on the cheek behind the post-orbital and jugal. This region is in the one case covered by three bones, in the other by four or five. Two of these the quadrato-jugal and the pre-operculum are obviously homologous and the only question left is therefore whether the two or three plates in *Holoptychius* have arisen by the fragmentation of the single large plate in *Glyptopomus*, whether they have fused to form the single plate of *Glyptopomus*, or whether the squamosal of *Holoptychius* has expanded crushing the others out of existence. Consideration of the actual form of the posterior border of the squamosal of *Glyptopomus* which provides a step in which the anterior corner of the pre-operculum is embayed

suggests that the squamosal has arisen from a more complex arrangement and is really formed by the fusion of the squamosal of *Holoptychius* with the other bones. This view is supported by the fact that in the obviously closely allied forms *Tristichopterus* and *Eusthenopteron* the same region is in the British form covered by three plates which are replaced by a single one in that from Canada. It is therefore not improbable that extensive fusions may have taken place between the bones of the head of Rhipidistians, a view which seems to receive additional support from the condition shown in the fronto-ethmoidal shield of these fish. The same line of argument will suggest that the small element which, in *Holoptychius* and *Glyptopomus* lies between the squamosal and the tabular, has in the probably more advanced forms fused with the operculum.

We have been fortunate in that our material has allowed us to describe, imperfectly it is true, the structure of the palate of two of these fish, a region which has hitherto been practically unknown. The most striking features of this palate are :—

(1) the presence of a single very large pterygoidal element which reaches back to clasp the posterior surface of the quadrate and extends so far forward as to articulate with the pre-vomers.

(2) the fact that in *Glyptopomus* this pterygoidal element articulates directly with the sides of the parasphenoid.

(3) that the pre-vomers are bones in the palate bearing large fangs.

(4) that there are distinct ectopterygoids and palatines bearing a row of teeth which may be represented only by a few large laniary teeth.

(5) that the outer edges of these bones are directly and

firmly articulated with the maxilla at its thin dentigerous edge.

(6) that in *Glyptopomus* there is a special foramen in the palatine, which is not merely a space left between two bones by imperfect ossification, but lies entirely in one bone. This opening agrees exactly with the internal naris of early Stegocephalia. It is quite certain that a suggestion, which has occurred to us, that it might possibly have served to receive the tip of a large tusk in the lower jaw in the way that an analogous foramen does in certain Stegocephalia, is incorrect, because it is far too large, there is no tooth in it, and there is no tooth in the lower jaw for it to receive. We leave to another occasion all discussion of the extremely important morphological questions raised by the occurence, in fish, of an external nostril lying above the junction of the maxilla and pre-maxilla, which is shown in our material of *Rhizodopsis* and even more clearly in *Megalichthys* material with which we are not concerned, and of internal nares on the palate, shown so clearly in our specimen of *Glyptopomus*.

We are glad to be able to confirm Dr. Traquair's description of a hyomandibular in *Rhizodopsis*. The very slight ossification of this element and the fact that it is apparently divided into two are of considerable importance, and the presence of a quite large foramen piercing its upper end is of still greater interest, for such a foramen is known in few fish and is a common feature in the stapes of early Amphibia and Reptilia.

Another interesting feature, so far as we know hitherto undescribed, is the occurrence of the spines or free scales associated with the pelvic fins which we have found in *Gyroptychius* and *Rhizodopsis*. It is not impossible that

a study of more satisfactory material will show that they exist in other members of the group. In the meanwhile their function must remain obscure.

The elongated scales which have long been known to occur behind the dorsal fins of the members of this group, although they bear a superficial resemblance to the pelvic spines, are certainly of very different significance, because they form part of the general squamation and are not free outstanding structures. They seem to have arisen in the following way. Since the time of Egerton it has been realised that there is a concentration of the endoskeletal supports at the base of the median fins shown for example by the articulation of a number of radials with a single basal element in the dorsal and anal fins of *Tristichopterus* and *Eusthenopteron.* This concentration implies an actual and real reduction in the width of the insertion of these fins. As shown extremely clearly in the specimen of *Holoptychius* which we have described, the median fins are provided with a fleshy lobe whose squamation is directly continuous with that of the body. When the base of the fin is notched in from the back a disarrangement of the squamation necessarily results, and we hold that the elongated ridge scales have simply grown forward to fill up the space so left.

The very marked resemblance which exists between the paired pelvic fins and the median fins in *Holoptychius* suggests very strongly that they are of similar origin, and that the median axis with paired radials which is the characteristic "archipterygial" fin, and which occurs in all Palæozoic Crossopterygian fishes, has been formed by a concentration quite similar to that which produced the dorsal fin of *Tristichopterus.* It is difficult to imagine that the primitive pectoral fin can have projected to such an immense distance from the body and that it should

have been of the great length which would have been necessary if it were to have given rise by a basal concentration to the elongated "archipterygial" fin of *Holoptychius* and we are therefore driven to the conclusion that the elongated type of "archipterygial" fin has arisen from a short fin similar to that of *Tristichopterus*.

The facts which we have brought forward throw doubt on the usefulness of the current divisions of the Rhipidistia. Fish so obviously closely allied as *Tristichopterus* and *Eusthenopteron* may differ considerably in their skull structure, whilst fish with so exactly similar heads as *Gyroptychius* and *Osteolepis* may have a family separation. The distinction between the families Rhizodontidae and Osteolepidae has been drawn essentially on the possession of "cycloid" scales in the one and rhombic in the other group. In other families of fishes, the Palæoniscidae, Semionotidae and Dapedidae for example such difference is not regarded as of family value, and known forms of Rhipidistia exhibit a transition from one type to the other. It is obvious that the condition of the caudal fin cannot be used for family division amongst these fishes, nor can we find any features in the skull which are more useful.

When we come to the Holoptychidæ we seem to have in the elongated pectoral fins a more satisfactory basis of separation, but the quite elongated pectoral fins of *Glyptopomus*, the discovery of which led Mr. Goodrich to place that fish in a separate family the Glyptopomidae, are really intermediate in form between the fins of *Rhizodopsis* and those of *Holoptychius*. It appears to us that only two courses are possible, to form a large series of families each containing fish which are obviously closely allied, which families would be at present impossible of concise definition, or a recognition of only a single family. As the institution of many almost indefinable families

would at present serve no useful purpose we prefer to leave the sub-order undivided referring to individual genera when smaller divisions become necessary.

By no means the least important outcome of Dr. Traquair's work on Old Red Sandstone fishes was his demonstration that it was possible to divide the Middle and Upper Old Red Sandstone into stages characterised by different faunas. The lowest of these, represented by the famous nodules of the Moray Firth localities, the quarry at Achanarras, and the district of Stromness in Orkney, yields a large fish fauna, the most significant member of which is *Pterichthys*. Succeeding these Stromness beds are the Thurso Beds, represented at the Hillhead Quarry, Dalcross, in Nairnshire, in the exposures round Thurso and near Kirkwall. These beds contain a majority of the fishes found in the underlying Stromness beds, but *Pterichthys* is absent and *Coccosteus minor* is added. The John o' Groat Beds which overlie the Thurso horizon yield only *Microbrachius*, "*Dipterus*" *macropterus*, and *Tristichopterus*, the first and last of which are restricted to them and have only been found on the shore at John o' Groat's and in the Deerness Quarry, Orkney. In the Upper Old Red of the Moray Firth region we have the Nairn horizon, which at Kingsteps yields *Asterolepis maxima*, *Holoptychius decoratus*, a *Coccosteus* and other fish. Overlying the Nairn Beds are those of Alves and Scaat Craig, of which the dominant fish is the great *Bothriolepis major*. Succeeding these are the Rosebrae Beds with *Glyptopomus*, *Phyllolepis*, and other peculiar fish.

It is of importance to discover where in this series the famous fish beds of Scaumenac Bay should be placed. As they yield *Bothriolepis* it is certain that they belong

to the Upper Old Red, and, as *Coccosteus* occurs in them, it seems probable that they belong to a low horizon in that group. This view is supported by the occurrence of Acanthodians and *Cheirolepis*, types which in England occur in the Middle Old Red. *Cheirolepis* has, however, been found in the Upper Old Red in Shetland associated with *Asterolepis*, which form itself does descend into the Middle Old Red, where it is found associated with "*Dipterus valenciennesi*"[4] above the Gloup in Deerness. *Bothriolepis*, however, does not occur below the Scaat Craig beds, although Mr. Taylor, of Lhanbryde, has found it in association with *Asterolepis* at Whitemire.

The marked resemblance between *Eusthenopteron* and *Tristichopterus* also supports this determination of the age, and we intend to regard the Scaumenac Beds as practically contemporaneous with those of Nairn.

Dipterus valenciennesi, Sedg. & Murch.

So far as we know no figure representing the arrangement of the plates of the head of this "species," the original of which was found in the Stromness horizon, has yet been published. There is in Manchester a single specimen collected by one of us at the Achanarras Quarry, which shows quite clearly the structure of the roof of the skull in this "species." This structure will be more clearly understood from the figures (*Pl. I., Fig.* 1; *Text-fig.* 8A) than from any description. The significant features are, the occurrence of a transverse series of three plates on the extreme back of the skull similar to the post-parietal and tabulars of a Rhipidistian, the anterior edges of which articulate with another transverse row also mainly composed of three plates. The middle one of

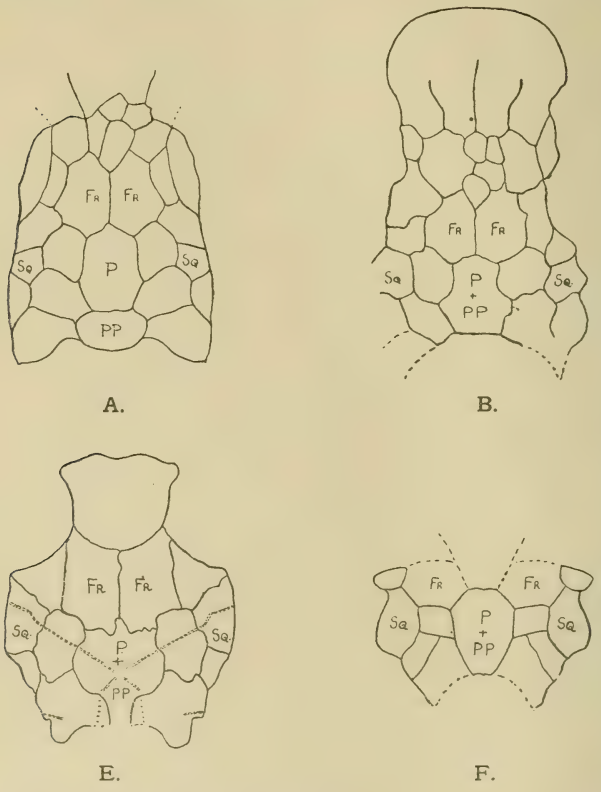
[4] We are not convinced of the identity of these fish with the typical *valenciennesi* of Banniskirk, although there are no obvious definable differences.

these is very large and its anterior end articulates with a pair of large plates which themselves support an azygous plate in front.

Dipterus platycephalus, Pander.

The structure of the roof of the skull, of the palate and of many other parts of the large fish whose remains occur abundantly in exquisite preservation, although in a disarticulated state, in the neighbourhood of Thurso, has been clearly described by Agassiz, Hugh Miller, Pander, Günther and Traquair. We give for the sake of comparison, a figure (*Text-fig.* 8. B) of the roof of the skull drawn from specimens in the Museum from the East Shore, Thurso. It will be noticed that this skull and the others which have been figured from the same horizon, differ from that described above from the Stromness Beds in the absence of the posterior row of three plates, which seem in them to have fused with those in front. Otherwise the two types have a great general resemblance. The large series of such specimens in the Museum, allows us to add somewhat to the accounts of the palate given by previous authors. The large skull here figured is unique in the fact that the well ossified brain case is scarcely if at all crushed. It shows a basi-cranial region whose posterior end is excavated by a large conical pit for the anterior end of the notochord. Its lower surface is not markedly convex, but is provided with a median ridge separating a pair of shallow grooves in each of which lies a small foramen. In this specimen the lower surface of the basis cranii is soon faulted down, but is shown, by a comparison of this and other specimens, to be covered by the posterior end of the rhomboidal parasphenoid which does not cover the whole of its lower surface. The lateral surface of the brain case rises vertically from the edges of

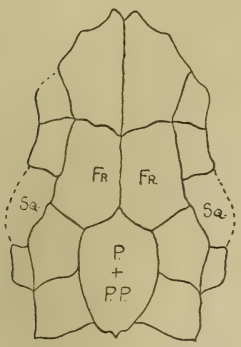
the basis cranii. At the back, on each side of the foramen magnum, it is vertically grooved and pierced by three foramina, the hindermost of which is really only a notch whose upper and posterior border is formed by the lower



Text-fig. 8.—Diagrams of the dorsal surface of the head of :— **A.**, *Dipterus valenciennesi*, (No. L. 8447.) Achanarras Quarry, Caithness. (Stromness Beds); **B.**, *Dipterus platycephalus*, (No. L. 10359) Thurso East shore. (Thurso Beds); **C.**, *Pentlandia macropterus*, (No. L. 10905) Newark, Orkney. (Deerness Beds); **D.**, *Scau-*

end of a crescent shaped bone which overlies the spinal cord and is unconnected with the brain case below. It is in fact obviously the neural arch of a vertebral segment incompletely fused with the back of the skull. It seems

not impossible that the ridging of the brain case in front of it indicates that other segments have recently fused with the primary chondrocranium. In front of this region the brain case gives rise to a powerful process



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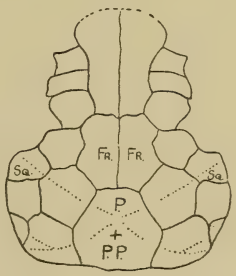

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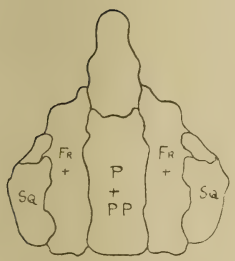

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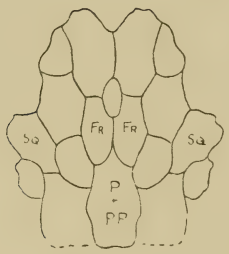
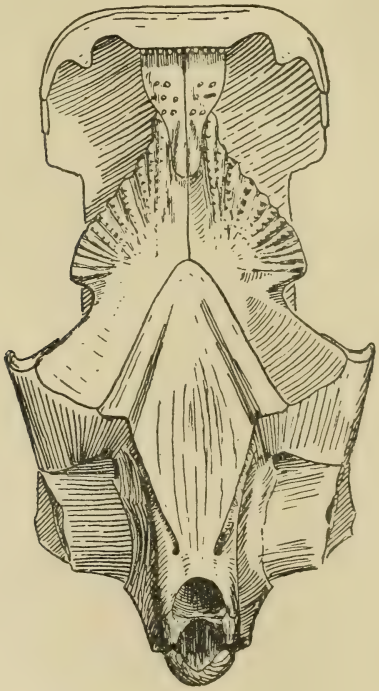


H.

menacia curta, (after Hussakof.); **E.**, *Phaneropleuron andersoni*, (No. L. 10867.) Dura Den, Fifeshire. (Rosebrae Beds); **F.**, *Sagenodus inæqualis*, (No. L. 10904), Upper Coal Measures; **G.**, *Ceratodus forsteri*, (after Goodrich); **H.**, *Ctenodus cristatus*, (modified from Smith Woodward), Middle Coal Measures. Reference letters as before.

which articulates with the roof of the skull, mainly indeed with the outer of the posterior row of three bones. Below this is an excavation in the side of the skull wall, marked off behind by a ridge which rises to the process and

below by another ridge. Although we have no direct evidence that such is the case, we believe that these ridges mark the position of the posterior vertical and horizontal semi-circular canals which in this case must be of great size, just as they are in the living *Ceratodus*. In advance of the otic region, the less well-ossified chondrocranium



Text-fig. 6.—*Dipterus platycephalus*, Pander. Restoration of the palatal aspect of the head with the circumorbital and opercular bones removed. Natural size.

joins the quadrate with which indeed it seems to be continuous. The general structure of the parasphenoid, pterygoids and quadrates has long been known, but we would note that the quadrate sends forwards a pterygoidal process in front of the quadrate ramus of the pterygoid, just as it always does in Stegocephalia.

Several of our specimens show quite clearly the presence of pre-vomers, which overlap the anterior ends of the pterygo-palatines, passing back between the ends of the large crushing "teeth" for some distance. They are quite large bones of somewhat feeble structure, and bear at least two and possibly three transverse rows of very small bluntly-pointed teeth. Anteriorly they reach forward to the lower edge of the cranial shield, with which they articulate in some way which our material does not clearly explain. We have observed a single row of similar small blunt teeth on the lower margin of the cranial shield between the notches which mark the position of the nostrils. These show that that region is really formed by the premaxillae.

The chief new features of importance shown by these specimens are those of the brain case. The evidence seems to us conclusive that the fusion of spinal elements with the back of the skull, which is so marked a feature of *Ceratodus* and which Barkas has shown to occur in *Ctenodus*, had already begun in *Dipterus*, although the parasphenoid had not at that time developed the remarkable posterior projection lying below the anterior part of the vertebral column which it subsequently acquired. Another striking feature of the brain case already noted by Traquair is its extraordinary complete ossification. The vomerine teeth of *Dipterus* have been previously figured by Goodrich in a restoration but are not quite accurately represented by him. Hussakof has figured vomerine teeth in *Scaumenacia*, but we shall show later that it is possible that these really belong to the premaxillae, although his identification may very probably be correct. The occurrence of a definite series of premaxillary teeth is interesting, as the similar teeth in the dentary were described by Traquair long ago.

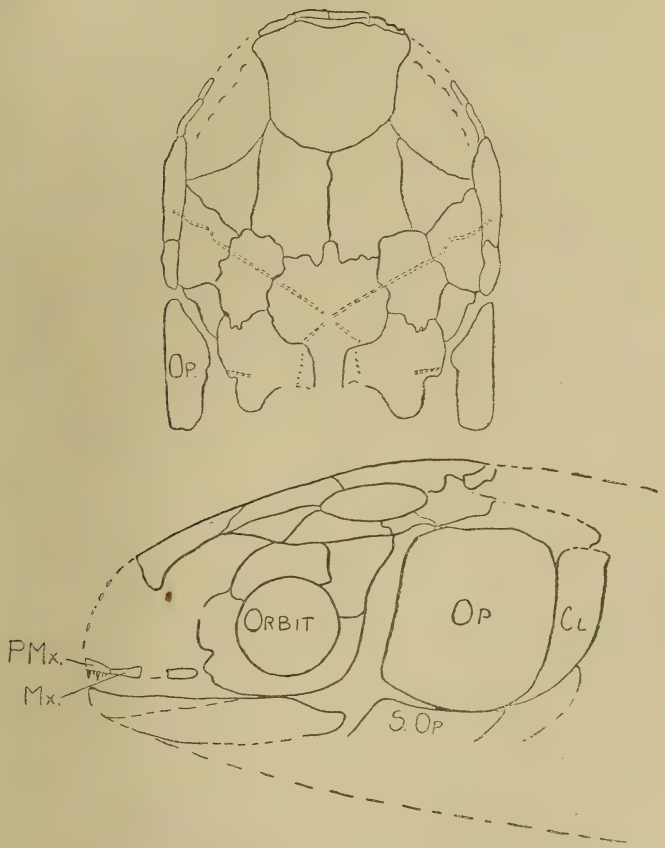
Specimen L 10863 shows the upper surface of the palato-pterygoids and of the anterior part of the parasphenoid very well, the most significant feature being the presence of a distinct ridge in the middle line formed by the fused pterygoids, which suggests that the whole of the upper surface of the palate was not in contact with the chondrocranium but only with a narrow interorbital septum. From the occurrence of a "fault" in the region of the quadrates which depresses the roof of the skull in most specimens of the head of *Dipterus* we are justified in concluding that there were no massive ossifications in the anterior part of the brain case corresponding to those in the otic region.

Pentlandia macropterus. (Traquair.)
Dipterus macropterus, Traq.

One specimen of "*Dipterus*" *macropterus* from Newark, Orkney, shows fairly clearly the structure of the top of the head, the bones being represented by an impression, squeezes from which are readily intelligible. The bones of the left side are in place, whilst those of the right are mostly displaced or missing. The figure given by Traquair agrees so far as it goes with our specimen, which however shows many additional elements. The significant features are, that the bones are loosely articulated, that there is no solid covering to the anterior end of the head, and that there are no median elements in advance of that which lies at the extreme back of the skull. This difference is one of importance. We shall show in a later part of this paper that it depends on the fact that "*Dipterus*" *macropterus* is a definite stage in the evolution of Dipnoi, derived from *Dipterus* and leading towards *Scaumenacia*; we therefore give it the new name of *Pentlandia*, after the strait which separates its two localities, John o' Groats and Deerness.

Phaneropleuron andersoni, Huxley.

This species is represented by excellent material on a slab from Dura Den obtained in the British Association's



Text-fig. 7. *Phaneropleuron andersoni.* Huxley. Dorsal and lateral aspects of the skull. Natural size. Reference letters as before, with :—P.Mx., Pre-maxilla.

diggings of 1913. The most valuable evidence is provided by a single almost uncrushed and excellently preserved head, but the more incomplete remains of three others enable us to check every feature which we describe.

Phaneropleuron has a broad depressed head with a nearly flat top and laterally placed orbits about half-way between the posterior end and the snout. The top of the head is covered with a shield of unornamented bones whose distribution is shown in the figure. This shield does not cover the whole surface of the head, a pair of large unossified areas being left in the antero-lateral regions. The orbit is surrounded by a single series of bones which unite with the dorsal shield posteriorly and above, but separate from it in front where they support a very small element directed towards the snout. This element on the right side of the best skull is in the same line as, and separated by only a very small interval from, another very slender element which itself touches the outer end of another small bone provided with a row of teeth. There seems no doubt that the more lateral element is the much reduced representative of the maxilla. The tooth-bearing bone may be either the premaxilla or the vomer. Its mode of articulation with the maxilla and the fact that it lies at the level of the extreme anterior end of the lower jaw suggests that it is more probably the premaxilla. It seems to have a slight extension on the palate which might be the case in either bone. The operculum is a thin rounded and remarkably large bone lying immediately behind the circum-orbital ring. Its lower margin is connected with the sub-operculum, of which we can give no account. Little is shown of the lower jaw beyond the fact that it extends from the back of the orbit to the end of the snout, and that it includes a dentary element apparently not fused with its fellow. There is a trace of a bone passing backward from the postero-lateral corner of the skull roof to the top of the clavicle, which is presumably a supra-clavicle. The clavicle itself is a large straight bone presenting no features of

interest. There is a large infra-clavicle passing within its lower end. Our specimens add nothing to the existing knowledge of the paired fins, but suggest, though we do not wish to insist that they prove, that there is some distinction between the dorsal fin and the upper lobe of the tail, and that the lower lobe of the tail is supported by a row of elements which articulate with the lower end of the haemal spines.

Sagenodus inæqualis. Owen.

The Manchester Museum contains a very remarkable specimen of *Sagenodus inæqualis*. This is preserved in a slab, apparently of cannel, containing specimens of a Lamellibranch which appears to be *Anthracomya phillipsi*. Will. and therefore suggests that the specimen comes from a horizon high in the Middle Coal Measures or in the Upper Coal Measures. It is almost certainly of local origin. The specimen shows the head of the fish with the lower jaw in position much crushed dorso-ventrally and viewed from the ventral side. The palate and lower jaw are in natural articulation, but the plates of the dorsal surface of the head have slipped backwards and to one side. They are somewhat broken and to some extent only represented by an impression but the whole shield agrees fairly well with those previously figured by Barkas and its plan is represented in *Text-fig.* 8 F. The anterior part of the parasphenoid with both palato-pterygoids articulated with it is well shown, the left upper tooth being beautifully displayed. On the right side the tooth and its supporting bone have been largely broken away so that they are represented by an impression of the dorsal surface and by a sectional view of their outer part. With this the corresponding lower tooth is in natural apposition. The bone which bears it is mostly removed but the inner

aspect of the angular which lies outside it is very well shown. On the left side the angular is incompletely represented mainly as an impression, and overlapping the angulars and quite symmetrically disposed at the front end of the head is a small bone which can only be a dentary.

Ctenodus ?

The Manchester Museum contains a large slab showing a good deal of the skeleton of a Dipnoan fish from the Jarrow Colliery, Kilkenny. It is a characteristic example of Huxley's *Campylopleuron*, as usual not showing structural details clearly, but of interest because it shows with perfect distinctness the presence of a pair of dentaries not fused in the middle line. Although it cannot be determined the interest of this fact, and the difference which it presents to the condition in *Sagenodus*, justify us in giving this short description.

If we arrange in order of age, as we have done in *Text-fig.* 8, the drawings of the dorsal surface of the skull in known Dipnoan genera we see at first glance that general resemblance between them which has long been known to exist but we find that *Dipterus valenciennesi* from the Stromness and *Dipterus platycephalus* from the Thurso horizons, *Pentlandia macropterus*, *Scaumenacia*, *Phaneropleuron*, *Sagenodus* and *Ceratodus*, form a series each member of which differs from that which precedes it in a constant way. Each step shows a reduction in the number of bones, and in each this reduction takes place at the anterior end. *Dipterus platycephalus* differs from *Dipterus valenciennesi* in the fusion of the posterior row of three plates with that which lies in front of them, and in a narrowing of its anterior part owing to a loss of two plates. *Pentlandia macropterus* has advanced over

Dipterus platycephalus in the breaking down of the great shield over the end of the snout and in the loss of that mosaic of small plates which in the older form separates the two main pairs of plates. *Scaumenacia*, as shown in Hussakof's drawing which we have been able to corroborate on a Manchester specimen, differs from *Pentlandia macropterus* in the narrowness of its anterior region and certain other details. *Phaneropleuron* differs from *Scaumenacia* in the loss of the lateral plates of the anterior half of its head and in the fusion of the chief anterior pair into one median bone. *Sagenodus* differs from *Phaneropleuron* either, in the loss of this new anterior median element and in the fusion of the only remaining pair of plates which meet in the middle line, or more probably by their separation through a thrusting back of this median element. *Ceratodus* differs by an extensive fusion of an antero-posterior row of plates.

This series has every appearance of being a true phyletic sequence illustrating that steady change in a definite direction which is so constant a feature of true phylogeny. It will be noted that these fish are the very ones and in the same order as those which Monsieur Dollo used to illustrate the production of the false diphycercal tail of *Ceratodus* from the heterocercal tail with separate dorsal fins of *Dipterus*. Any attempt to read this series in the reverse direction, which, on account of the occurrence of *Uronemus* with continuous median fins, and of a Dipterine fish with two small separate dorsals in the Rosebrae Beds at Elgin, might have been attempted if the condition of the fins alone were taken into account is now impossible, for none will be found to suggest that the skull of *Ceratodus* is more primitive than that of *Dipterus*. In any case the first known appearances of these fishes in exactly the right order is itself far too

important a point to be overlooked. We have therefore shown that so far as concerns the dorsal surface of its head *Ceratodus* is a morphological descendant and very probably a real descendant of *Dipterus*. Dollo has already shown the same fact so far as concerns the median fins.

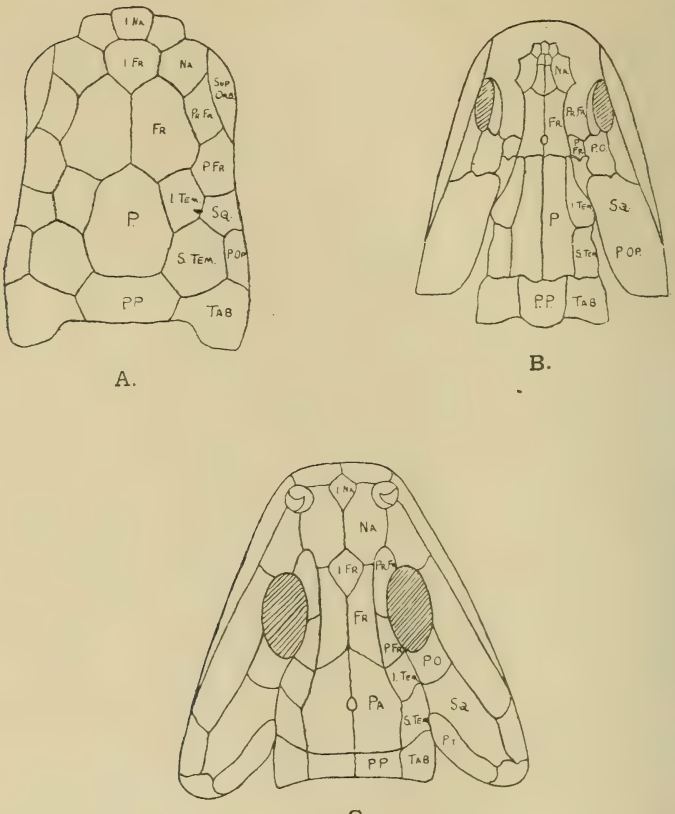
Passing on to other independent structures we find that in side view there is a very striking resemblance between the heads of *Ceratodus* and *Phaneropleuron*, the differences being mainly due to the further reduction of the circumorbital and other bones. *Phaneropleuron*, however, is in this region as in others obviously derived by deficient ossification or by reduction from *Scaumenacia* which itself has undeniable resemblances to *Dipterus*. It will be noticed that in all these genera the ridges of the dental plates radiate from a point, and that there seems to be a gradual reduction from twelve ridges in the palatine tooth of *Dipterus platycephalus*, to seven in *Scaumenacia*, six (seven ?) in *Phaneropleuron*, six in *Sagenodus*, five in *Ceratodus ornatus* (Middle Trias, South Africa), four and a rudiment in *Ceratodus latissimus* (Rhaetic) again suggesting that we have to do with a real genetic series. *Ctenodus*, whose skull roof has not at present entered into our discussion, differs from the members of this series in its dentition, in the fact that the ridges on the teeth are sensibly parallel, there being from twelve to fourteen ridges in *Ctenodus interruptus* from the Lower Carboniferous of Scotland, twelve to fourteen in *Ctenodus cristatus* from the Middle Coal Measures, and twenty in *Ctenodus murchisoni* from the Upper Coal Measures. It thus apparently differs from the members of our series not only in the parallelism of the ridges but also in their tendency to increase in number.

If the diagram of the top of the head (*Text-fig.* 8, H)

be compared with the other drawings in that figure, it will be obvious that it cannot have been derived from any form after *Dipterus platycephalus* because of the occurrence of a median element separating two principal pairs of plates, which is lost in *Pentlandia macropterus* and subsequent stages. We therefore hold that *Ctenodus* is not closely connected with *Sagenodus* but represents a different line long separated from it, which has a rapid and different specialisation of its teeth, and is very conservative in the top of its head. *Uronemus* is another Dipnoan which is obviously not a member of our series, if the account of its teeth given by Dr. Traquair is to be relied on. The specimens in Manchester of *Uronemus splendens* only show one row of bluntly pointed apparently flattened teeth the meaning of which is somewhat obscure; they have been regarded by Dr. Traquair and Dr. Smith Woodward as marginal teeth, but the evidence so far as we know it does not completely exclude of the view that they really represent the larger ends of the ridges of dental plates perhaps very narrow in their palatal expansion and perhaps with an exaggerated row of teeth along the outer edge.

It now remains to consider the relation of the Dipnoi to the Rhipidistia. We have shown that the skull of *Dipterus valenciennesi* is the base of our series, and it is the most primitive Dipnoan skull known. In *Text-fig.* 9 we have placed it alongside a representation of *Osteolepis*, into which we have introduced the supra-orbital plate of *Glyptopomus*, and a division of the squamosal so that it includes all bones known to occur in the skull of the Rhipidistia, so that it is really a schematic representation of the most primitive form of skull in that order. For clearness the circumorbital and cheek plates are represented somewhat broadened. Comparison of these figures will

show that except for the fusion of parietals and of a small anterior pair of elements the two match bone for bone,



Text-fig. 9.—Dorsal views of the skulls of:—**A.**, a primitive *Dipterus* with the circumorbitals, maxillae, pre-maxillae, etc., omitted. Slightly schematic from No. L. 8447; **B.**, a primitive Rhipidistian (*Osteolepis* with the supra-orbital of *Glyptopomus* inserted); **C.**, a primitive Stegocephalian with all the bones known to occur in the skulls of members of that group. Reference letters as before, with:—I.FR., Interfrontal; I.NA., Inter-nasal. (Interfrontal known in *Eryops*, etc. Inter-nasal in *Microphalis*.)

except that two small bones which lie on the extreme outer sides of the roof of the skull in *Dipterus* and which

by our series are shown to be homologous with the "squamosal" of *Ceratodus* are not at first sight represented in the roof of the head of *Osteolepis*. Our finest skull of *Dipterus platycephalus* shows that these plates cover the upper end of the quadrate, in this agreeing with the "squamosal" of *Ceratodus*.

It will be noted that they carry part of the broad belt of pits for the reception of lateral line sensory organs. Their connection with the quadrate at once suggests that they are represented by the squamosal and bones associated with it in Rhipidistia, as we know that these are actually applied to the lateral border of the quadrate. It will be remembered that these cheek plates in Rhipidistia do actually support a lateral line canal although, as we have been unable to trace anything more than a very broad parallel between the general distribution of lateral line canals in *Osteolepis* and *Dipterus*, such evidence is not of any great value. The fact that up to now no representatives of the cheek plates which form so large an element of the Rhipidistian skull have been found in Dipnoi, has always been troublesome to those who believed in their close connection. It remains to be shown that it is possible to explain the methods by which this reduction of the cheek plates to two small bones on the top of the head has been brought about, and the reasons for this reduction. It is obvious that the Rhipidistia, taken as a whole, are a group of predacious fish living mainly on other fishes. In many cases the massing of large fins at the end of the body shows that they were active rapid-swimming fish built for pursuing others. The Dipnoi, on the other hand, have always been slow swimmers, probably becoming slower as time went on. Their flat crushing tooth plates are often very badly worn, suggesting that their owners either lived on molluscs, the

hard shells of which they had to crush, or that they fed on water weeds, which carried sand into the mouth. In any case it is obvious from the dentition that their diet required powerful mastication. It is a general rule, applicable not only to fish but to reptiles and mammals, that animals which live by the active pursuit and capture of fish have elongated jaws which provide them with a wide gape and by the oblique insertion of muscles into them a very rapid snapping action. Those forms, however, which have developed a powerful crushing dentition (*e.g.* *Placodus* and the Tortoises) have short jaws powerfully built and muscles inserted on to them at right angles. They close their jaws more slowly and then develop pressure on the food. If we compare *Dipterus* with any Rhipidistian we find that the extreme shortness of the jaw in the former is a very striking feature, which is associated with the fact that its quadrate is inclined forwards whilst that of the voracious Rhipidistian is always directed backwards, and is always associated with an oblique suspensorium. We therefore suggest that, starting from a stage resembling *Osteolepis*, the Dipnoans, during the gradual concentration of their teeth, resulting in the establishment of a crushing dentition, have gradually shortened their jaws by a swing forwards of the lower end of the quadrate, a process which has squeezed the cheek plates between the circumorbital bones and the operculum until they have vanished entirely from the side of the head and only remain in the triangular notch between the quadrate, the edges of the "supra-temporal" and "inter-temporals," and the post-orbital, as illustrated in figure.

SUMMARY.

In the foregoing paper we have described in detail and given restored figures of the skulls of *Holoptychius*,

Glyptopomus, *Osteolepis*, and of the whole fish of *Rhizodopsis*. These studies have shown that the Rhipidistian skull is considerably more complicated than has previously been supposed but that there is a great similarity amongst all members of the group. We have described certain new features connected with the fins which lead us to conclude that the short type of paired fin found in *Eusthenopteron* is older than and has given rise to the biserial "archipterygial" fin of *Holoptychius*. For the first time we have been able to give a detailed description of the feebly ossified hyomandibular of *Rhizodopsis* which recalls the stapes of *Eryops* in being perforated by a foramen near its proximal end. In the same fish we have been able to describe certain features of the cartilaginous brain case. In *Rhizodopsis* and *Glyptopomus* we have given an account of the palate which considerably extends our knowledge of the structure of this region,, and has a very important bearing on the problem of Amphibian ancestry. We describe for the first time the structure of the skull in *Phaneropleuron*, and show that *Dipterus valenciennesi*, *Dipterus platycephalus*, *Pentlandia macropterus*, *Scaumenacia*, *Phaneropleuron*, *Sagenodus*, and *Ceratodus* form a phylogenetic series showing how *Ceratodus* is derived by a process of specialisation and reduction from *Dipterus*. *Uronemus* and *Ctenodus* are shown to belong to different lines of descent, and the conclusion is reached that *Dipterus valenciennesi* is the most primitive as it is the oldest known Dipnoan. Its skull is then compared with that of a generalised Rhipidistian and the two are shown to agree bone for bone the differences being entirely dependent on the totally different adaptations of the two types.

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EXPLANATION OF PLATES.

Plate I.

Fig. 1. Head of *Dipterus valenciennesi*, Sedg. and Murch. × $\frac{3}{2}$. Achanarras Quarry, Caithness. L. 8447. M.M.

Fig. 2. Pelvic region of *Rhizodopsis sauroides*, Will. Ventral aspect. × 2. L. 8323. M.M.
Knowles Ironstone, Fenton, Staffs.
P.F., Pelvic Fin; P.SP., Pelvic Spine.

Fig. 3. Head of *Tristichopterus alatus*, Eq. Ventral aspect × $\frac{1}{2}$. L. 8429. M.M.
Deerness Quarry, Deerness, Orkney.
P.OP., Preoperculum; SQ., Squamosal.

Fig. 4. Pectoral fin and second dorsal of another individual of *Glyptopomus Kinnairdi*, Hux. × $\frac{2}{3}$. L. 10867. M.M.
Dura Den, Fifeshire.
PEC., Pectoral Fin. D^2. 2nd Dorsal Fin.

Fig. 5. Dorsal aspect of the palate of *Glyptopomus Kinnairdi* × $\frac{4}{5}$. L. 10867. M.M.
Dura Den, Fifeshire.
PAL., Palatine; P.N., Posterior nares; P.V., Prevomer; PT., Pterygoid.

Fig. 1. × $\frac{3}{2}$.

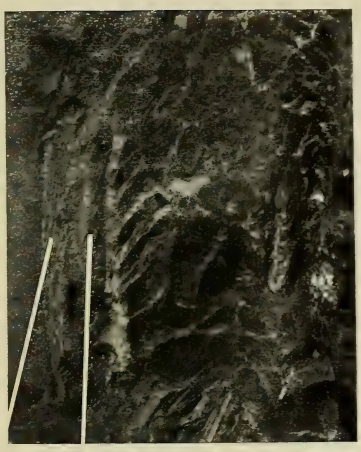

Fig. 2. × 2.

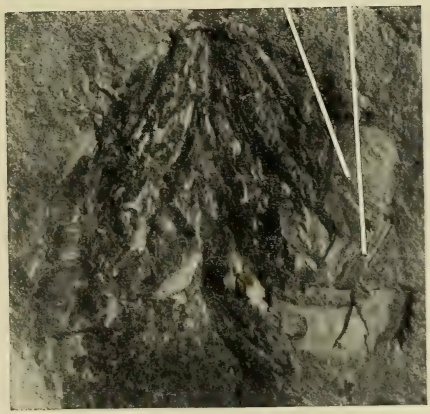

Fig. 3. × $\frac{1}{2}$.

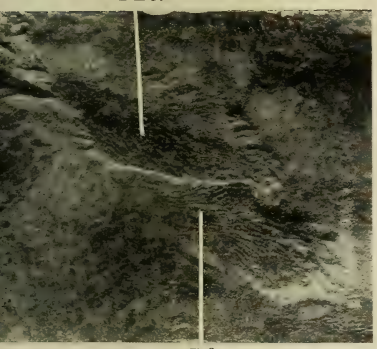

Fig. 4. × $\frac{2}{3}$

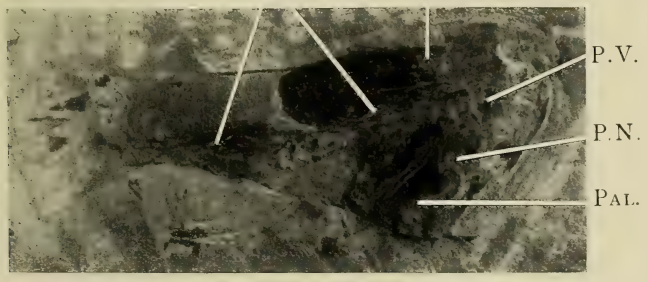

Fig. 5. × $\frac{4}{5}$

Plate II.

Fig. 6. *Tristichopterus alatus*, Eq., posterior part of fish × $\frac{3}{5}$.
L. 10866A. M.M.
Deerness Quarry, Deerness, Orkney.

Fig. 7. *Holoptychius Flemingii*, Ag., posterior part of fish.
× $\frac{2}{3}$. L. 8485. M.M.
Dura Den, Fifeshire.

Fig. 8. *Glyptolepis paucidens* (Aq.). Part of vertebral column × $\frac{2}{3}$. L. 10915. M.M.
Achanarras Quarry, Caithness.

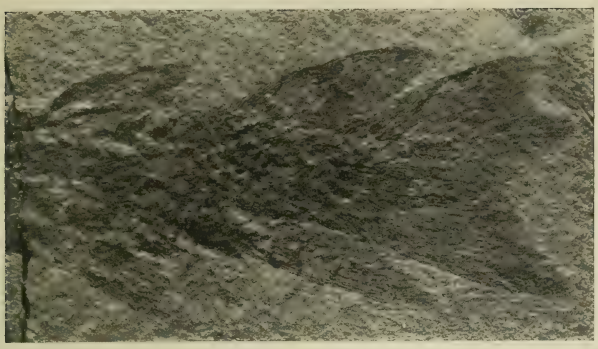

Fig. 6. $\times \frac{3}{5}$.

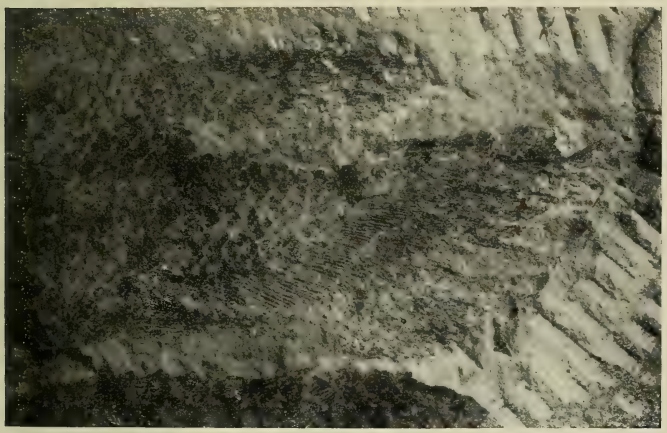

Fig. 7. $\times \frac{2}{3}$.

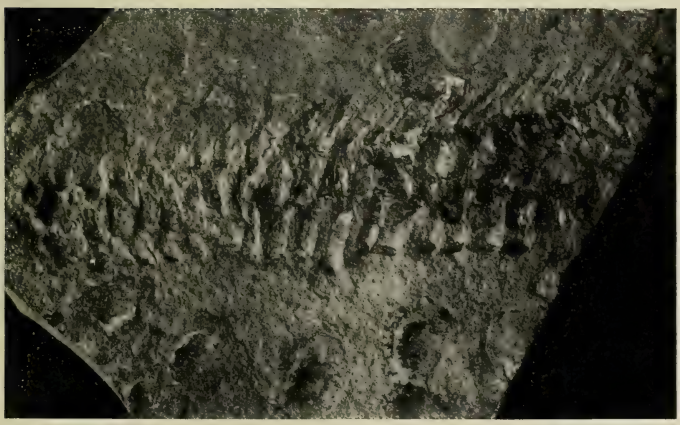

Fig. 8. $\times \frac{2}{3}$.

Plate III.

Fig. 9. Ventral aspect of crushed head of *Sagenodus inæqualis*, Ow. × $\frac{2}{3}$. L. 10904. M.M.
ANG., Angular; DEN., Dentary; PAR. +, Parietals and post-parietals; PAR. SP., Parasphenoid.

Fig. 10. *Phaneropleuron Andersoni*, Hux. Dorsal aspect of head × ·93. L. 10867. M.M.
CIRC.-ORB., Circumorbital plates; OP., Operculum; PAL., Palatine; P.MX., Premaxilla; SP., Splenial tooth.

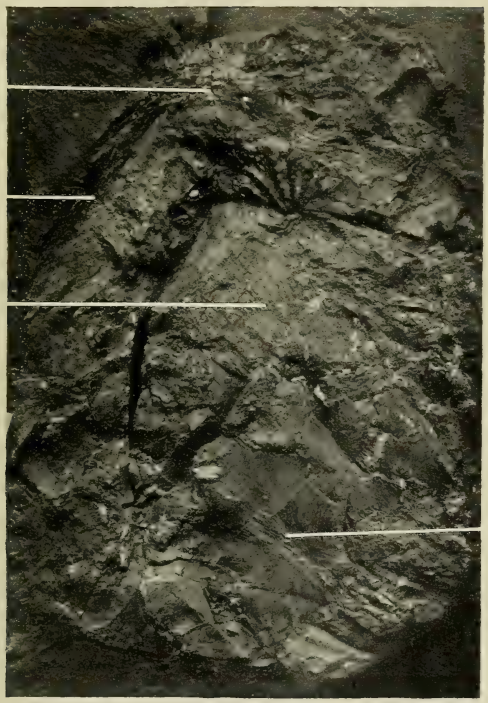

Fig. 9. × $\frac{2}{3}$.

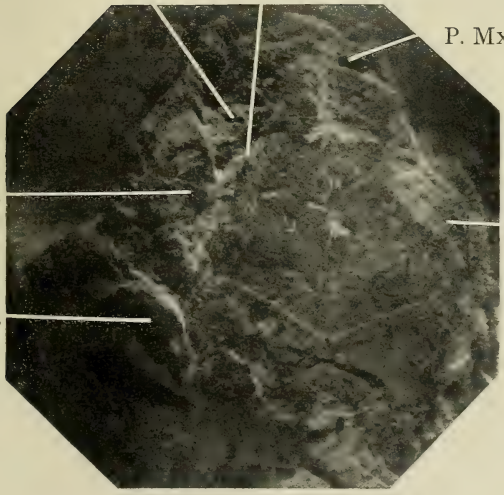

Fig. 10. × ·93.

Manchester Memoirs, Vol. lx. (1916), *No.* 3.

III. A Change in the Habits of the Black-headed Gull.

By T. A. Coward, F.Z.S., F.E.S.

(Received and read November 30th, 1915.)

In 1910 Charles Oldham and I drew attention to the fact that numbers of Black-headed Gulls roosted nightly in autumn and winter on Rostherne Mere.* No special notice has, however, been taken of the remarkable change in habit which this fact denotes.

The Black-headed Gull, *Larus ridibundus* Linn., is the most abundant British gull, and is far commoner in inland localities than any other species. It frequents the coasts, follows up rivers and canals, is plentiful on inland waters and feeds freely on sewage farms and fields at a considerable distance from the sea. I have seen it feeding on the sewage farm at Water Orton, as central a locality in England as one can imagine.

Within the last twenty-five or thirty years the bird has steadily and rapidly increased ; all recent writers on ornithology comment on this fact. There is every reason to believe that this increase dates from 1880, when effective legislation gave protection to Wild Birds. At first the increase was little noticed, and it was not until the hard winter of 1894-95 brought large numbers into the Thames and the starved birds became more or less tame that the public generally noticed their presence. After this Black-heads came regularly into London every winter,

* "Vert. Fauna of Cheshire," I., 428.

and many people imagined that they remembered the welcome that they had received, failing to realise that the numbers had increased and that the birds' winter range was extended.

For many years after this the appearance of the bird, or of any gulls inland, was thought to be either an indication of rough weather at sea or an augury of storm. Judging from remarks which appear in the press from time to time, this idea still prevails to some extent. Whatever may have been the case prior to this time, the presence of gulls inland is mainly if not entirely due to one of two facts—the increase in numbers enforcing an enlarged feeding area, or to passage migration. Every spring and autumn large numbers of Black-headed and lesser Black-backed Gulls travel through England, as well as along the coasts, and other species pass, though not in such noticeable numbers. The Black-headed Gull, though abundant all the year round, is one of our most migratory birds, but there is apparently no racial custom nor hereditary family tradition to regulate whether the birds from any particular area shall winter at home or travel to the Mediterranean or African shores.

The colonial nesting haunts of the species are marshes, islands on lakes, or saltings; the first two may be miles from the sea and at considerable altitude. There are numerous and extensive colonies on the Pennines, the Welsh moors, the Cheviots and the Lake Country uplands. Others are on low-lying marshes either near the sea or inland; the only large Cheshire colony is in the most open but least frequented portion of Delamere Forest. Some of the Cumberland and Lancashire colonies are amongst sandhills, and at least two in the latter county are on tidal saltings, where, as a rule, at least once during the nesting season the whole marsh is submerged, swamp-

ing the eggs and young. Here the birds' intelligence fails them ; in spite of the fact that a brood is annually destroyed they return again and again to the same spot.

When the young are able to fly some of them move to tidal estuaries or the shore, but others may never visit the coast. It is not, of course, possible to make any dogmatic statement about the movements of young birds ; they may visit the coast and return inland many times ; but this we do know, that so soon as young gulls are able to leave the Cheshire gullery young birds may also be seen feeding on the neighbouring meres, from which, except for a few weeks, they are never absent. This, however, is not the destination of all young birds reared in Cheshire, for birds ringed at Delamere have been met with in a variety of places. After the breeding season the Black-head is common in inland Cheshire, but is most abundant in the river valleys or near large sheets of water. Round Delamere the bird is known as the "sea-crow," either from its habit of following the plough or from its somewhat corvine voice.

Not only in Cheshire but in most parts of our islands this gull is steadily extending its inland range ; we may now look upon the Black-head as an inland as well as a maritime bird. It is not, however, this general change of habit, which of course includes a change of diet, which I wish to emphasise, but a secondary and local change caused by the primary one.

Anyone who has lived or stayed for any length of time beside a tidal estuary or bay must be well aware that this garrulous gull feeds at night as well as by day ; tidal flats are at their best for a few hours twice in the twenty-four, when the waters are receding, and the birds if they can see at all do not waste those precious hours of the ebb. Coastwise feeding gulls rest by day or night

when the tide is running, but they do not need to be in sight of the water to judge the right moment to leave the roosting for the feeding ground.

The inland feeding Black-head either knows nothing about tides or ignores their influence; they have ceased to regulate its feeding times; it roosts, like any other diurnal bird, when it gets dark. This, at any rate, is the case with the gulls which frequent the country to the south of Manchester, say between the Lancashire border and Knutsford. Every afternoon, a little before dusk, these birds leave their scattered feeding grounds in the fields, the Carrington sewage works, and the various meres and pools, and trail to Rostherne, where in a compact mass or masses they roost on the water. In the Dee and Mersey estuaries the gulls rest during the flow on the mud flats or marshes, sleeping or preening their feathers; on the coast they congregate on the shore, or in fields, selecting positions from which they can command a wide view to guard against the approach of enemies. The centre of a large water like Rostherne gives them even more security. Foxes, men, or other foes cannot steal upon them.

In most animals hereditary habits survive long after they have ceased to be of practical use; one would imagine that the habit of regulating feeding hours according to tides would have persisted amongst these birds, which only a few years ago were maritime feeders. How is it that certain birds of the same species, which feed in contiguous areas in the country south and east of the Mersey estuary should have distinct habits? Some of the birds near Warrington, for instance, must fly in a westerly direction to feed whenever the tide ebbs, and others, but a little further away, travel south at the approach of dusk to roost at a time fixed relatively to sunset.

In November the gulls begin to gather at Rostherne soon after 3 p.m. On the 5th, although only one bird was visible at 3-15, over 300 were on the water by 3-30. In the fading light it is impossible to count the birds accurately, but towards the end of October I have seen so many as 500 on the water by 3-30. Throughout autumn and winter a number of Black-heads feed on the mere at Tatton, and during the afternoon, just before dusk, these birds rise in a body, as if by word of command, and fly straight to Rostherne. Birds from the north and north-west, which have been feeding along the Mersey valley, arrive singly or in parties; twenty, fifty or even a hundred may come in at once, and when there are a number together they usually fly in chevron formation. As a rule the earliest birds fly round in a body before finally settling down, but the later arrivals drop straight and join those already on the water.

It is exceedingly difficult to arrive at any estimate of the numbers which thus roost together; one can count those which pass over one portion of the bank, but the light, when the majority are coming in, is too far gone to enable one to see those arriving from elsewhere. When, however, from three to five hundred pass over a sky area not more than a quarter of a mile wide, it is fair to guess that at least three times this number may reach the water from other points; an estimate that a thousand birds are often gathered together is probably far short of the actual number. Indeed, on one winter evening, by counting a group and multiplying by the whole area covered by the settled birds, I estimated a thousand on the water and a couple of hundred more passed over me as I left the mere. On moonlight nights, the keeper tells me, the clamour from this multitude is extraordinary.

Almost certainly the increase of the Black-headed

Gull is as much due to its ability to change habits as that the changed habits are due to increase. Psychologically the Black-head is an adaptive bird ; consequently it succeeds in the struggle and overcomes difficulties which would spell disaster for a less go-ahead species. It is bound by no hard and fast limits in the matter of food ; the failure of any particular supply does not handicap it. It can adjust its habits to marine or inland conditions. It is a winner in life's race as a direct consequence ; thus its numbers increase.

Prior to Wild Bird Protection two serious dangers threatened the welfare of the species ; its eggs were systematically robbed, and its young, when just able to fly and still lacking experience, were ruthlessly slaughtered by gunners. Egg-collecting and casual shooting were checked by legislation, and at once the bird increased. Individual competition was overcome by the bird's natural aptitude ; it altered its habits so as to minimise the evils of congestion. This change from a variable feeding time to a constant diurnal habit, not as regards the species as a whole but only so far as it favours individuals, is perhaps the most extraordinary divergence from hereditary habits in the life history of this progressive bird.

VOL. 60: PART II.

MEMOIRS AND PROCEEDINGS

OF

THE MANCHESTER LITERARY & PHILOSOPHICAL SOCIETY, 1915-1916.

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IV. The Money Cowry (*Cypræa moneta*, L.), as a Sacred Object among North American Indians.

By J. Wilfrid Jackson, F.G.S.

Manchester Museum.

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(Communicated by Professor G. Elliot Smith, M.A., M.D., F.R.S.)

(Received and read December 14th, 1915.)

In a paper on "'The Midē'wiwin' or 'Grand Medicine Society' of the Ojibwa,"[1] the author, W. J. Hoffman, gives some interesting particulars regarding the use made of the money cowry, *Cypræa moneta*, L., in ceremonies connected with the initiation of a candidate to the society of medicine men. A somewhat similar account, by the same author, is also given in his article on "The Menomini Indians."[2]

The use of this particular cowry amongst the Indians is of great interest; in the first place, owing to it being alien to the American continent, and in the second place, in view of its adoption for religious and other purposes in different parts of the Old World.

This well-known species is an inhabitant of the Indo-Pacific seas and is not known to occur on any of the coasts of the Americas. Its nearest habitat to that continent is probably the Sandwich Islands.

As a medium of exchange no other species of shell, or

[1] *Bureau of Ethnology* (United States), *7th Ann. Report*, 1891.

[2] *Id.*, *14th Ann. Report*, 1896, pt. i.

May 17th, 1916.

form of shell-money, has had so extended a use as the money cowry, *C. moneta*. It is in use as money in India and many parts of Africa. In India about 4,000 pass for a shilling. The use of the cowry for money in India has a very considerable antiquity. In Bengal the principal money finds, belonging to the period prior to Alexander the Great, have been cowries, the metallic moneys being comparatively few.[3]

In the Sudan, so far as the people trade, they have no other currency than the cowry, of which 2,000 shells, weighing seven pounds, are worth a dollar.

According to Pickering,[4] this species was formerly used as money in the Sandwich Islands.

Del Mar (*op. cit.*, p. 19) also speaks of the use of cowries as money in China in ancient times, and further remarks (p. 147) on the use of cowries for money in trade carried on between India and Egypt, and China and Egypt, at a very remote period.

Thus a series of cultural links are established by this cowry-currency which can be joined up to form a complete chain from the Sudan to America.

As an ornament, the money cowry has been used in many ways. The Dyaks stick the small white shells in the eye sockets of the skulls of their enemies, which they keep. In India these shells are much used to ornament the trappings of horses and elephants. They are also strung like beads or sewed like buttons on their dress by Brinjari women as personal ornaments.[5]

In Africa it is used to a considerable extent for decorative purposes.

Cypræa moneta has been met with in several pre-

[3] A. del Mar, "Hist. of Money," 1885.

[4] "Races of Man," Bohn's ed., 1863.

[5] Stearns. *Rept. U.S. Nat. Mus.*, 1887 (1889), pt. ii.

historic sites in Europe and Asia at considerable distances from its habitat, and other cowries of larger dimensions have been discovered in pre-historic pit-dwellings and Saxon graves, in our own country, and in Franco-Merovingian graves in France.

The cowry is often referred to in the classics as Concha Venerea, and the presence of cowry-shells in graves, etc., is looked upon as due to the part they played in ancient times in connection with the cult of Venus, as symbolic of the generative forces of nature.

The Ojibwa and Menomini Indians are both tribes of the Algonquian family, which was more extensive than that of any other linguistic stock in North America, their territory reaching from Labrador to the Rocky Mountains, and from the Churchill River of Hudson at least as far south as Pamlico Sound of North Carolina.[6]

The Ojibwa, according to Hoffman (*op. cit.*, 1891, p. 147), is one of the largest tribes of the United States, and it is scattered over a considerable area, from the Province of Ontario, on the east, to the Red River of the North, on the west, and from Manitoba southward through the States of Minnesota, Wisconsin, and Michigan.

The Menomini Indians, more nearly related to the Ojibwa than to any other tribe, are located on a reservation in the north-eastern part of Wisconsin (Hoffman, *op. cit.*, 1896, p. 12).

Constant intercourse between the Menomini and Ojibwa has influenced the ritual of the former's medicine ceremonials. It is moulded very perceptibly after the Ojibwa's, but during the process of adaptation much of the ancient ritual has been lost and the ceremonies are much curtailed and apparently worn down by careless transmission from generation to generation. Living side

[6] J. W. Powell, *Bureau of Ethnol., 7th Ann. Rept.*, 1891.

by side from the earliest historical times, their medicine ceremonials present a remarkable similarity.

The origin of the Grand Medicine Society, the Midē'wiwin of the Ojibwa and Mitä'wit of the Menomini, is buried in obscurity. In this society, as maintained by the Ojibwa, are preserved the traditions relating to cosmogony and the genesis of mankind, to the appearance on the earth of an anthropomorphic deity whose primary services consisted of interceding between the Good Mystery and the Indians. It is looked upon by them as "their religion," as they themselves designate it.

The hero-god of the Ojibwa is Mī'nabō'zho; of the Menomini, Mä'näbŭsh, both meaning "Great Rabbit," because of his ability to perform great deeds. The method pursued by him is dramatically rehearsed at the initiation of a candidate into the medicine society.

This society, which consists of an indefinite number of both sexes, is graded into four separate and distinct degrees, although there is a general impression that any degree beyond the first is practically a mere repetition.

At ceremonies held by this society the chief article of value is the medicine sack, containing several small sacred articles, and particularly the small white money cowry—mī'gis, of the Ojibwa; konä'pamik, of the Menomini—used in shooting at the candidate for admission to the society and in conveying sacred or mystic influence to a patient. During the ceremonies, which are prolonged to a considerable extent in order to impress the candidate and other observers with the importance and sacredness of the proceedings, the initiate is acquainted with the tradition of the creation of the Indians, the descent to earth of the servant of the Good Spirit, who acted in the capacity of intercessor and mediator, and the traditions relative to the migration of the Ani'shinâ'bēg—the

original people. The sacred emblem—the money cowry—is shown to him and he is told how it came into the possession of the medicine men through the hero-god, Mä′näbŭsh or Mī′nabō′zho. Much dancing and tobacco smoking[7] is indulged in, and each medicine man in turn breathes on his medicine bag and pretends to shoot it at the candidate's breast. The magic influence contained in the medicine bag having been shot into the candidate's heart, and, being too powerful for him to bear, he becomes unconscious and falls forward on his face. It is believed that if the small sacred shell be swallowed by the medicine man, all he is obliged to do to transfer his power to the medicine bag is to breathe on it, the mysterious power and influence being then transmitted by merely thrusting the bag toward the desired object or person. The whole number of assisting medicine men gather round the prostrate body of the candidate and lay their medicine bags on his back, where they remain during the chanting of certain phrases by the chief medicine man. Each man then stoops to get his bag and the chief then places his hand under the candidate's forehead and raises it slightly from the ground, when a sacred cowry drops from the candidate's mouth.

The whole of the ceremonies are carried out in a specially constructed medicine tent, which must always be built so as to extend from the direction of the rising sun to the direction of the setting thereof.

Amongst the Menomini the sacred shell appears always to be the money cowry, *Cypræa moneta*,[8] but according to Hoffman, amongst the Ojibwa, it consists of

[7] The tobacco smoking among N. A. Indians seems to be connected with the idea of sacrifice and propitiation.

[8] The example figured by Hoffman, *op. cit.*, is interesting, as it is perforated at one end as if for suspension.

a small white shell, of almost any species, but the one believed to resemble the mythical mī'gis is similar to the cowry, *C. moneta.* He states that nearly all the shells employed for initiation purposes are foreign species, and have no doubt been obtained from traders. I doubt very much if this is the case with the money cowry, as there is little evidence of trade in this Indo-Pacific shell amongst the Indians. The fact of other shells being used by the Ojibwa seems to imply that the money cowry is scarce among them, and those they possess, doubtless handed down from generation to generation, are regarded with special veneration as being like that mentioned in the tradition of Mī'nabō'zho and the origin of the Midē'-wiwin, or Grand Medicine Society.

A particularly suggestive event is figured by Mallery in his paper on the "Picture-Writing of the American Indians,"[9] which appears to me to have some connection with the cowry shell-cult of the Ojibwa and Menomini. In *Fig.* 825 (p. 577) he reproduces what he calls "a dangerous trading trip," an episode taken from a birch-bark record, known to have been more than 70 years old, obtained in 1882 from the Ojibwa Indians at Red Lake, Minnesota. This was interpreted by an Indian from that reservation, although he did not know the author nor the history of the record. It represents an Indian who visited a country supposed to have been near one of the great lakes. In his hand is a scalp taken from the head of an enemy, after having killed him. His enemy is represented by a man wearing horns on his head, a common symbol of superior power among medicine men. Of the other figures on the record one represents a shell, and denotes the primary object of the journey. It is stated in the Indian's interpretation that shells were needed for

[9] *Bureau of Ethnol., 10th Ann. Rept.*, 1893.

making ornaments and to trade, but the shell figured on the record is undoubtedly a cowry. This fact is significant, and one would be justified in concluding that the pictograph commemorates no ordinary trading trip, but an expedition to secure some especially noted sacred shell possessed by a rival medicine man.

As bearing upon the shell-cult just described, the following account is of peculiar interest. Long, in his "Expedition from Pittsburgh to the Rocky Mountains," 1823,[10] tells us that the Omahas possessed a sacred shell which they transmitted from generation to generation. Its origin was quite unknown. A skin lodge was built for it, and a man appointed as guardian, who resided in the lodge. It was placed on a stand and never allowed to touch the earth, and was concealed from sight by a number of mats made of skins plaited. The whole formed a large package, from which tobacco, roots of trees, and other objects were suspended. No one dared to open all these coverings in order to see the shell, for if they attempted to look upon it they were struck with instant and total loss of sight. The sacred shell was taken by the Indians on all their national hunts, and was also consulted as an oracle before any expedition was made against an enemy. The medicine men seated themselves round the sacred lodge, the lower part of which was thrown up like a curtain, and the external mat was carefully removed from the shell, that it might have air. Some of the consecrated tobacco suspended from the coverings of the shell was taken by the medicine men and smoked to the "Great Medicine." During this ceremony everyone listened most attentively, hoping to hear a sound proceed from the sacred shell. At length someone imagined he heard a noise resembling a forced

[10] As quoted in "Flint Chips," by E. T. Stevens, pp. 448-449.

expiration of air from the lungs, and this was considered a favourable omen, and the tribe prepared for the expedition, confident of success. If, on the contrary, the shell obstinately remained silent, the result of the expedition was regarded as doubtful.

This reverence paid to shells by the Indians of North America has many parallels in the Old World. In West Africa the natives in the Yoruba country have a cowry shell house for a cowry shell god, the whole being entirely made up of the money cowry.

The natives of Usambara, in East Africa, also attach marvellous powers to a species of *Achatina*, imagining that it can ward off all forms of evil and witchcraft. The shell is held in high repute and placed in little enclosures of stone in their fields, and at the gateways of their villages, which are thus considered safe from the attacks of the enemy or from disease.[11] The name of the species is not given, but it may possibly be the *Achatina bloyeti* var. *fatalis*, a species which plays a part in the trials by ordeal of the Wadshagga peoples, the accused whose guilt or innocence is to be proved being compelled to take the poison from it.[12]

In Asia we have the well-known chank-cult which is current in India, Thibet, and China.

In Polynesia one of the most interesting examples is that recorded by the Rev. Mr. Hadfield, who came across a fine specimen of the Orange Cowry (*Cypræa aurora*) in a native hut in Lifu, Loyalty Is., where it was held in much veneration by the occupant, who considered it a kind of fetish.[13] Mr. Hadfield also gives some further

[11] K. Johnston, "Notes on the Geology of Usambara," 1879, as quoted by Lovell "Edible British Mollusca," 1884, p. 198.

[12] Tryon's "Manual of Conchology," 2nd Ser., xvii., 1904, p. 37.

[13] See Melvill & Standen, "Lifu Mollusca," *Journal of Conchology*, viii., 1895, p. 112.

interesting information relating to this species. He tells us that Mrs. Hadfield came upon a rare treasure in the shape of a fine Orange Cowry which according to the native report had been found by an old woman who was struck on the forehead by a demon, who asked her why she took the shell. The woman, it is stated, died from the effects of the blow.[14]

APPENDIX.

Since this paper has been printed I have discovered a most remarkable parallel in the use of the money cowry in West Africa. In his description of the Human Leopard Society of the Sierra Leone cannibals,[15] Major R. G. Berry, A.S.C., gives detailed particulars of the contents of a Borfimor, or medicine bag, used by Leopard-men in the initiation of a person desirous of joining the society. This Borfimor bag, now in his possession, figured prominently in a trial which led to the hanging of thirty-two men. On being opened it was found to contain four smaller bags, one of which contained two tau-shaped iron crosses, the stems of which were lapped with cotton, and to the top of each was tied a cowry shell, or sign of life. "The tau cross, or *crux ansata*," Berry remarks, "was the emblem of Osiris, and is called the Sign of Life, the symbol of resuscitation and new birth, expressive of the idea entertained by the Egyptians and other philosophers, that nothing created was annihilated, and

[14] Melvill & Standen, *op. cit.*, p. 131.

[15] R. G. Berry, "The Sierra Leone Cannibals, with Notes on their History, Religion, and Customs." *Proc. Roy. Irish Academy*, Vol. xxx., Sect. C., No. 2, May, 1912, pp. 45, 53, and 67.

that to cease to be was only to assume another form, dissolution being merely the passage to reproduction. In its association with the Borfimor we seem to have the reflection of some such ideas, the fetish being animated by the indwelling life of the victim and the spirit attracted to it" (p. 67).

The Borfimor bag also contained a pebble made of some earthy matter and lime, in one side of which was incorporated a cowry shell.

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V. The Aztec Moon-cult and its relation to the Chank-cult of India.

By J. Wilfrid Jackson, F.G.S.,

Manchester Museum.

(Communicated by Professor G. Elliot Smith, M.A., M.D., F.R.S.)

(Received and read December 14th, 1915.)

The interesting evidence brought forward by Dr. Elliot Smith before this Society, and in *Nature*, November 25th, 1915, p. 340, and December 16th, p. 425, regarding the transmission from India or the Far East to America of the design of an elephant's head does not stand alone as an indication of an element of Asiatic culture traceable in the old Mexican civilization.

Though the Mexican mythology is so complex, anyone who carefully compares the Aztec and Hindu pantheons cannot but conclude that the former is derived to a very large extent from the latter. The whole subject, however, is far too vast to be discussed in this short paper. I propose, therefore, very briefly to deal with a most remarkable identity in the use of large conch shells as trumpets and in the adoption of shells as religious symbols.

Beyond figuring and describing the various shells depicted on Mexican manuscripts, no one, so far as I am aware, has hitherto called attention to their true significance.

May 17th, 1916.

In Professor Seler's monograph on the Codex Vaticanus and elsewhere, the Mexican Moon God is represented associated with a large marine snail shell as its symbol.

As the emblem of the moon the snail's shell is also shown with the figure of a man, or merely a hand, emerging from the mouth—the God in the Shell—which might have reference to the waters being pent up, or possibly to different phases of the moon. The Rain God, Tlaloc, is thus seen emerging, and holding lightning in both hands. The snail was also brought into association by the Aztecs with conception, pregnancy, and birth. Snail shells were also connected with the cult of Chantico, the Fire Goddess, and are figured as breast ornaments of Quetzalcouatl, the Wind God, Tepeyollotli, the Heart of the Mountains, etc.

In one place the Moon God appears as another form of Xochipilli, the God of Flowers and Food Supplies, and in another place he appears as the God of the Dance and Music.

Turning to India, we find the same general ideas prevailing in the chank-cult of the Hindus.

The Chank *(Turbinella pyrum)* is one of the two important symbols associated by Hindus with Vishnu and his many avatars or incarnations. Siva, also, is sometimes represented holding the chank. Such an association is of peculiar interest when one considers the worship of the chank in the daily liturgy of the Brahmans. Taking the shell in his hand, the Brahman recites the following prayer :—

"At the mouth of this shell is the God of the Moon, on its sides is Varuna, on its back Prajāpati, and on its apex, the Ganges, the Sarasvati, and all the other sacred rivers of the three worlds in which they make ablutions

according to the command of Vāsudeva.[1] In this chank is the chief of the Brahmans (Brahmendra or Brahmanaspati). This is why we worship the sacred chank. Glory to thee, sacred shell, blessed by all the gods, born in the sea, and formerly held by Vishnu in his hand. We adore the sacred chank and meditate upon it. May we be filled with joy!

"I offer (to the chank) everything needful for worship—perfumes, rice and flowers."[2]

In India the moon is believed to preside over the growth of crops, etc., and in certain places, and especially in Siam, the inauguration of the ploughing season is celebrated by the Minister of Agriculture being borne on a palanquin to the field, accompanied by priests blowing loud blasts on chank shells. In Malabar, also, at the bringing in of the first fruits, the priest comes forth from the local temple, preceded by a man blowing a conch-shell trumpet.

Thus we find embodied in the above prayer, and in the harvest rites, the very elements which make up the moon-cult of the Aztecs. Associated with the chank we have (*a*), the God of the Moon, and (*b*), Varuna, the Hindu god of the waters and of the west quarter, who is worshipped as one of the guardian deities of the earth, and in times of drought and famine. He is represented in paintings as a white man seated on Makara, a mythical crocodile. This god recalls Tlaloc, the Mexican Rain God, who is sometimes associated with the crocodile, and, as previously mentioned, is depicted as emerging from the conch-shell. (*c*), Prajāpati, "the father of all creatures," a personification of the sun, is emblematical of creation and birth. The snail or conch-shell, as we have seen,

[1] One of the names of Krishna.

[2] Hornell, "The Sacred Chank of India," 1914.

was also associated with conception and birth by the Mexicans.

The offerings made to the chank of the fruits of the earth; the harvest rites accompanied by conch-shell music; and the use of shell-trumpets in Hindu temple worship, have their counterparts in Mexican manuscripts in the figure of the God of Flowers and Food Supplies being carried in procession preceded by a priest blowing a conch-shell trumpet,[3] and in references to the blowing of conchs in the temples at midnight as a signal for the priests to arise and mortify themselves, to sing, and then to go in procession to the bath.[4]

In India both the ordinary and the rare and highly prized sinistral forms of the chank are employed in temple-worship, and it is not a little curious to find that in the Mexican pictures both forms are also shown. It is quite possible that here, as in India, the sinistral form may have had a special significance.

It is altogether inconceivable that people so far apart as India and Mexico could have independently associated the conch-shell with the moon and adopted it as the symbol of their Moon God, in addition to using it as a trumpet, and one may justly conclude that we have here definite proof of the transmission of an element of culture from the Old to the New World.

If any further evidence is needed regarding the similarity in the moon-cult of these two people, it is provided by the fact that the ancient Mexicans, like the Hindus, regarded what we call the "Man in the Moon" as a rabbit, and explained the present fainter brightness of the moon by the myth that the gods flung a rabbit in the face of

[3] See Edward Seler, "Codex Vaticanus, No. 3,773," 1902, Fig. 363, p. 162. The shell figured, by the way, is a reversed *Cassis cornuta.*

[4] *Ibid.*

the moon, which originally shone as brilliantly as the sun. Strangely enough Dr. Seler points out this fact in his description of the Codex Vaticanus, but makes no further comment.

In Aztec picture-writings the moon is figured—usually as a nasal crescent of bone with a rabbit seated in a watery field—beside the Goddess of Filth—the old Huaxtec Earth Goddess.

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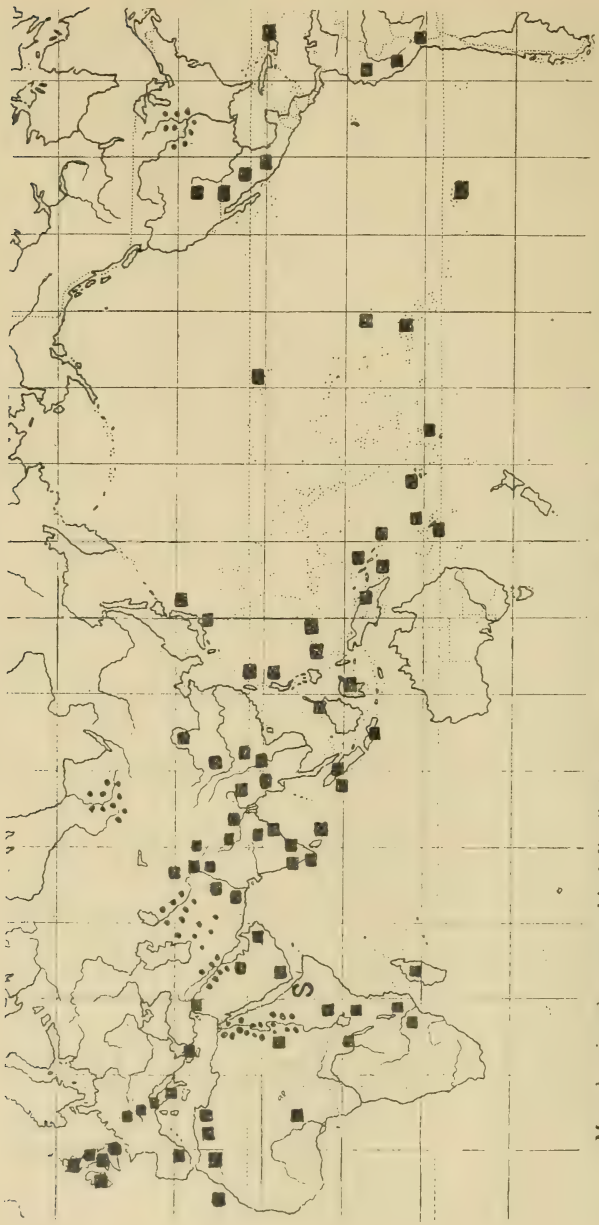
VI. The Geographical Distribution of Terraced Cultivation and Irrigation.

By W. J. Perry, B.A.

(Communicated by Professor G. Elliot Smith, M.A., M.D., F.R.S.).

(Received and read February 8th, 1916.)

The series of communications which are being made by Prof. Elliot Smith to the Manchester Literary and Philosophical Society is designed to demonstrate the magnitude and far-reaching nature of the cultural influence associated with the practice of building megalithic structures. In this communication I propose to put forward the results of a survey of the practice of cultivating by means of artificially built-up and irrigated terraces. During the course of an investigation into the extent and nature of the influence of an immigration of builders of megalithic structures upon the cultures of the indigenous peoples of the East Indian Archipelago and the Burma-Assam region, the evidence, derived from native traditions as well as from the distribution of various kinds of stonework, the cult of the sun, sacred chiefs, phallic ornamentation, and so forth, agreed in ascribing the practice of terraced irrigation to these stone-using immigrants. A wider survey was instituted into the distribution of this strange mode of cultivation in other parts of the world, and the results of this survey will now be put before you. These results are not yet complete, but they represent in broad outline the area of distribution of the practice. Details are yet lacking with regard to many places, but



Map showing the geographical distribution of Terraced-cultivation (squares).

The areas indicated by smaller spots are the sites of methods of cultivated and irrigation which are probably related in different ways to the use of terraces.

I put forward the results gained up to the present in the hope that they will help in the discussion of the thesis which Prof. Elliot Smith is maintaining.

The method of cultivating the soil by means of terraces constitutes one of the most remarkable examples of the gigantic amount of labour which can be expended by communities of human beings in order to procure food. By means of retaining walls, generally of stone, and with earth often laboriously transported from elsewhere, huge staircases of fields are made upon the sides of mountains; and a teeming population is supported in places where otherwise life would be difficult. These terraces are generally supplied with water, which is often brought from a distance; and some peoples in the past have, as will be shown, performed stupendous feats in the construction of irrigation systems, and have displayed an astonishing knowledge of hydraulics.

The method of exposition adopted will be mainly by means of quotations, for one of my aims is to lay stress upon the intense astonishment expressed by travellers who have examined systems of cultivation by means of irrigated terraces.

The survey will begin with Europe and will then work eastward through the Mediterranean. Then we shall proceed by way of Africa to Arabia, India, China, Japan, and thence right across the Pacific to America.

Terraced cultivation was once practised in Great Britain. It is mentioned by Sir Laurence Gomme[1] in a work in which will be found a discussion of the terrace-cultivation of Britain and the problems arising out of its existence there. Sir Laurence Gomme gives accounts of terraced cultivation in Wiltshire, Dorset, Hampshire, Sussex, Bedford, Herts (and between Cambridge and

[1] "The Village Community." New York, 1890, pp. 72, 75-95.

Hitchin), Carmarthenshire, Llangollen, Yorkshire, the Cheviots, the Tweed valley, Peebles, Argyle, and in several parts of Ireland. Some of these terraces were supported by stone walls.[2] Sir Laurence Gomme says:— "Although of one place Mr. Chambers states 'there is no trace of masonry in there construction,' he says of the ground round Dunsapie that 'it is quite evident that (the terraces) have been carefully formed with a facing of wall composed of rough blocks, and the faces of some of them are so well defined and steep that it is barely possible to climb them,' and 'the pastoral ground over which they extend has many rough blocks scattered over it.'" Sir Laurence Gomme goes on to say "Now though there does not appear to be any sign of such constructive evidence in the more southern examples, it is open to remark that the lapse of ages account for the stone facing having been gradually removed, or that in some districts where stone was not plentiful some other material was used for the purpose of construction. For instance, of the Wilts examples Mr. Scrope says the late Mr. Cunningham informed him that it was 'a practice to dig in these lynchets for flints.'"

Among others, Canon Greenwell mentions terraces in England.[4] He says "terraces of a peculiar construction are found throughout large and various districts of Britain. They still remain in some parts of the Wolds, as for instance near Carnaby. . . . . These terraces have been considered by many persons, and I think with every probability, to be the places upon which some cereal crop was grown under a system of agriculture not quite intelligible to us."[5]

[2] *Op. cit.*, pp. 76, 89.
[3] *Op. cit.*, pp. 89-90.
[4] "British Barrows," Oxford, 1877.
[5] *Op. cit.*, p. 114.

In the Craven district of the West Riding, says Canon Greenwell, "there are abundant examples of these peculiar terraces, which, found on the slopes of hill-sides, were at one time supposed to mark ancient levels of water, but which are, notwithstanding, clearly of artificial origin. . . . . It is not easy to understand why such elaborate works, calling for no slight expenditure of labour, should have been constructed to aid the growth of any crops; for though in some cases, where they occur upon a steep hill-side, they might be needed to prevent the washing away of the soil when it was broken up, and therefore more subject to the action of water, in other cases they are found upon slopes lying at such an angle as obviously to preclude the necessity of such a provision.[6] Canon Greenwell describes terraces in the East Riding, Westmorland, Durham and Northumberland, "Indeed, in the county last named, some of them are found on the precipitous sides of the porphyritic hills on the banks of the river Breamish, at such an elevation as to make it difficult to believe that any cereal crop could ever have grown upon them."

Miss Semple[7] says, "In Britain of the Bronze Age, before the peoples of Aryan, speech began to swarm over the island, the primitive inhabitants involved in constant clan or tribal warfare, placed their villages on the hills, and left in the indestructible terraces on their slopes the evidences of a vanished race and an outgrown social order."

The next place where I have definite information about terraces is Spain. Miss Semple says that terraced cultivation was brought in by the Saracens from Arabia,

[6] *Op. cit.*, p. 374

[7] Ellen Churchill Semple, "Influences of Geographic Environment on the Basis of Ratzel's system of Anthropo-Geography," 1911, p. 563.

but I doubt this. "They built walls of heavy masonry, and brought water, loam and fertilising materials from great distances. The slopes of Granada back of Malaga and Almeria were covered with vineyards. Every foot of land susceptible of cultivation was turned to account, every drop of water from the ill-timed winter rains was conserved for the growing season. The application of intelligence and labour to tillage enabled the Hispano-Arab provinces to support a dense population.[8] Terraced cultivation is found in Germany, Switzerland and Italy.[9] Malta has many terraces with masonry walls to sustain them. "In the Cyclades every patch of tillable ground is cultivated by the industrious inhabitants. Terraced slopes are green with orchards of various southern fruits, and between the trees are planted melons and vegetables."[10] Again, "To-day, terraced slopes, irrigation, hand-made soils, hoe and spade tillage, rotation of crops, and a rich variety of field and garden products characterise the economic history of the Mediterranean islands, whether Elba, the Lipari, Ponza, Procida, Capri, Ischia, Pantellaria, Lampedurs or the Ægean groups."[10]

The Phœnicians practised irrigation and terraced cultivation in the plains of Sidon.[11] "Terraces are especially found on Mount Lebanon. When viewed from the sea on a morning in early spring, Lebanon presents a picture which once seen is never forgotten; but deeper still is the impression left on the mind when one looks down over its terraced slopes clothed in their gorgeous foliage." The Phœnicians had a water supply brought through stone aqueducts into masonry-lined reservoirs.[12]

Terraced cultivation was once practised in Palestine. "As to the present condition of the country: In the plains

[8] Semple, p. 567. [9] *Ibid*, p. 566. [10] *Ibid*, p. 457.
[11] Rawlinson, "History of Phœnicia," London, 1889, p. 8.
[12] *Op. cit.*, pp. 10, 17, 18, 36, 73.

the soil is wonderfully rich, and wells can be sunk, though at considerable depths; the hillsides are bare, the soil having tumbled to the bottom of the deep steep valleys. The white skeletons of the old system of tenancy still visible on the bare mountain sides, and the roots of trees still peering from the rocky fissures attest the fact that the hill country of Palestine was once cultivated in a satisfactory manner. Walls of rough stone were built round the hill-sides, three to four feet high, according to the steepness of the slope, and the space between them and the hill filled in with fat loam, then another wall, and another, from bottom to top until the mountain side presented the appearance from the opposite hills of a series of steps."[13]

The Berbers of North Africa practise terraced irrigation, and along the Saharan slopes of the Atlas piedmont run a series of wadis and artesian wells.[14] Irrigation is found in the Saharan oases: for example, that of L'Oeud-Rir in Algeria is formed of irrigated gardens separated by stone walls.[15]

The irrigation systems of Egypt and Mesopotamia are well known. The lives of the vast majority of Egyptian peasants have for thousands of years been chiefly occupied with the irrigation of the soil and the problems of the water-supply. The method of procedure which is characteristic of Egyptian irrigation is to divide the land up into compartments, and to allow the water to flow from one sector to the other.

Terraced cultivation is present in Darfur of the Egyptian Sudan. Only the mountainous districts are well

[13] Sir C. Warren, *Scottish Geographical Magazine*, in Herbertson's Descriptive Geography of Asia, London, 1913.

[14] Semple, p. 501.

[15] Dr. H. Weisberger, "Notes sur L'Oeud-Rir et ses habitants," *Revue d'ethnographie*, IV., 1885.

watered and thickly populated, and small terraces for grain and melons cover all the slopes.[16] Among the Wakamba and associated tribes of East Africa "the artificial irrigation of their fields is a conspicuous achievement."[17] The tribes of the Baringo district of East Africa are all experts at irrigation, "Of which they make use to an astonishing extent. For instance, the whole of Ndo, which is ten or twelve miles in length, is with the exception of the last two miles at the north end watered by ditches taken from a single river." This will appear the more remarkable when we consider the limited size of the population.[18] The Kalika "a tribe of serfs . . . south of Makaraka, land in 3 N, have extensive fields with stalks of durra as tall as a man . . . . small patches planted with lubia, ... pasture meadows on the gently sloping hills, cut up in all directions by little watercourses, brooks, deep channels."[19] Werner says that the tribes of British Central Africa plant maize "where there are bits of alluvial soil close to a watercourse, which are either kept moist by the stream or can be easily irrigated."[20] Terraced cultivation is also found in Nigeria among the Angoss, "a savage negro tribe who occupy part of the Murchison range in Northern Nigeria." They have mapped out all their sloping land into little terraces, sometimes only a foot or two wide."[21]

Terraced cultivation is found in the Canaries. "On the precipitous slopes of Teneriffe, every particle of alluvial soil is collected to make gardens.[22]

Among the Marunga who live on the west face of the

[16] Semple, p. 571.

[17] Ratzel, "History of Mankind," II., p. 524.

[18] Hon. K. R. Dundas, "Notes on the tribes inhabiting the Baringo District, East Africa," *Journal Royal Anth. Inst.*, XL., 1910, p. 64.

[19] Ratzel, III., p. 79.

[20] "British Central Africa," London, 1906, pp, 178-80.

[21] Semple, p. 570.

[22] *Ibid*, p. 569.

rift valley, containing lake Tanganyka, we are told that, "Here Cameron found the surface not regularly terraced, but retaining walls of loose stones dispersed at intervals, which serve to hold the soil in place, without greatly altering the natural slope. The scene recalled the terraced heights of Switzerland, and the people working there looked like flies on a wall."[23]

Still further to the south terraced irrigation has been carried on to a remarkable degree in Rhodesia. Hall, in an account of the Inyanga ruins, situated 250 miles north of Great Zimbabwe says, "On the summits of the hills are stone forts, possibly a hundred of these structures, while up the sides of the hills, from base to summit, are stone terraces. Round their lower flanks run stone aqueducts, each, one, two or three miles in length." He further remarks that "the great extent of country covered with these remains is simply marvellous." He goes on to say in another place, "one of the most extraordinary features of the Inyanga Range is the vast number of old aqueducts, some two miles or more in length, running from artificial dams on the mountain streams, and crossing from hill to hill in a most remarkable manner. "Whoever constructed these aqueducts must have been a people thoroughly conversant with engineering, for their levels are beautifully and exactly carried out in spite of all natural obstacles, and not an inch of fall is wasted throughout the length of their courses. These are a marvel to all modern engineers who inspect them. Evidently they were used for purposes of irrigation. . . " And again he says :—"Perhaps the feature which most strikes the visitor to this district is the hill terraces. These are found in hundreds.

"These terraces cover the hills from base to summit,

[23] *Ibid*, pp. 570-1.

but mainly on their northern side. As many as forty terraces, one above and behind the other, are to be found on any one hill. Most of these have earth behind them, but from the inner sides of some the soil has in the course of time been washed away. They have retaining walls, and most probably were used for horticultural purposes. Hill terraces also cover a small area as far south as Swaziland." [24]

Irrigated terraces are also found in Madagascar. "The chief employment of the Malagasy is agriculture. In the cultivation of rice they show very great ingenuity, the *ketsa* grounds, where the rice is sown before transplanting, being found in either on the margins of streams or in the hollows of the hills in a series of terraces, to which water is often conducted for a considerable distance. In this agricultural engineering no people surpass the Betsiléo." [25] Arabia is a place where terrace irrigation is and has been carried out on a huge scale. The Saracens who entered Spain, "had come from the severest training-school in all Eurasia. Where the arid tableland of Arabia is buttressed on the south-western front by high coast ranges (6,000 to 10,500 feet or 2,000 to 3,000 metres) in Yemen, rich in its soil of disintegrated trap rock, adequately watered by the dash of the south-west Monsoon against its towering ridges, but practically the whole country is atilt. Consequently the mountains have been terraced from the base often up to 6,000 feet."

"The country presents the aspect of vast agricultural amphitheatres, in which the narrow paths of ancient paving zigzag up and up through successive zones of production. . . . The terrace walls are from five to

[24] Hall, "Stone Forts and Pits on the Inyanga Estate, Rhodesia." *Jourl. Roy. Anth. Inst.*, XXXV., 1905.

[25] "Encyclop. Britt.," XIth Edition, XVII., p. 274.

eight feet high, but toward the top of the mountains they often increase to fifteen feet. Though lined without mortar, they are kept in perfect repair. Reservoirs filled with water from the two rainy seasons supply the irrigation channels. In the narrow valleys of the Nejd plateau in central Arabia and on the mountain slopes of Oman are found the same irrigated gardens and terraced plantations." [26]

Mesopotamia, Persia and Central Asia, together with Afghanistan and Beluchistan have, or have had in the past, extensive irrigation systems.[27] Mr. Cresswell mentions several districts west of Persia in Chinese Turkestan such as Kashgar, Yarkand and Khotan where extensive irrigation has been carried out. (Cf. also Semple, 359.) The careful irrigation of Geok Tepe astonished the Russians when they arrived there.[28] Terraced irrigation is found in the provinces of Sze Shuan and Shen-shi in China,[29] "In south-west China there are two or three ranges between Ch'ung-Ch'ing and Lu-chou with summits about 2,000 feet above the sea, but little hills and narrow valleys form the distinctive features of this country. The rock is a soft sandstone and shale, often much displaced. The softness of the stone makes terraced cultivation very easy, and this system is carried to greater perfection here than in any other part of China. Crossing one of the little cols, and looking on the valleys that break away from it, one is struck by the thought of the sum of human labour expended to bring rugged hills into such complete subjection, and one receives a most lively impression of the

[26] Semple, p. 567.

[27] See an exceedingly interesting and suggestive article by K. A. C. Cresswell, "Fluctuations in the Population of Irrigated Countries." *Man*, 1915, 40.

[28] Ratzel, III., p. 331.

[29] Semple, pp. 568-9.

patient industry of this wonderful people. From peak to valley the whole hill-side has been levelled into terraces, so that not a foot of ground is lost. More than this, the terraces are cut up into fields—beds would be better words—averaging 50 feet by 40 feet, perfectly level, and enclosed by narrow banks. The outside bank of each bed has a rough sluice to regulate the level of the water, any surplus, after the ground is sufficiently covered for paddy, falling into the bed below, and so on till the bottom of the valley is reached."[30]

Terraced irrigation is wide-spread in northern India. It is found in Kashmir, where "the terraces are irrigated by contour channels constructed along the hill-sides, which bring water for miles from distant snow-fed streams." Again, "the mountain sections of the native states of Nepal and Bhutan present the view of slopes cut with gigantic stairs, each step a field of waving rice kept saturated by irrigating streams from abundant mountain streams. Further north, where the Himalayas and Hindu Kush meet, terrace agriculture is combined with irrigation in the high Gilgit valleys, and farther still along that mere gash running from the Pamir dome, called the Hunza valley. Here live the once lawless robber tribes of the Hunzas and Nagaris, ... whose extensive terraces of irrigated fields and evidences of skilful tillage are strangely at variance with the barbarous character of its inhabitants."[31] Irrigation is carried out in the valley of the Sutlej, and in western Thibet in the Taklahat district.[32] We are further told that "the western political boundary of the Sind extends into the barren foothill of Baluchistan

[30] Gomme, *op. cit.*, p. 96, quoting from Blue Book, China, No. I., 1888, p. 2.

[31] Semple, p. 568.

[32] C. A. Sherring, "Western Thibet," London, 1906, pp. 336, 168-70, 209. Semple, p. 572.

only as far as the affluents of the Indus render the land arable by irrigation."[33] Miss Sykes speaks of terraced irrigation between the Mashkid and Rakshan valleys in Baluchistan. "All about this part of the country were traces of a once wide-spread civilisation and the ruins of many apparently large towns. The whole of the valleys were terraced, tier upon tier of low slate walls often reaching some way up the sides of the hills."[34]

Irrigated terraces are found in Ceylon, where they extend right up the sides of the mountains and are accompanied by extensive irrigation works.

The Ho Mundas of Chota Nagpur have terraced irrigation. " . . . the terraced *dōn* lands testify to the dogged perseverance and indefatigable industry of the Mundas. Years of patient labour of whole families of Mundas were spent in embanking hill-streams, levelling river-beds and valleys, cutting into stubborn ground higher up, and forming them into little terraces of *dōn* lands. Generation after generation of Mundas have toiled in the heat and in the rain to prepare their terraced rice-fields. And still they go on patiently reclaiming waste lands and preparing *dōn* lands, as their forefathers had done before them."[35]

The Khonds of Orissa have village fields "formed in a succession of terraces, to which water is conducted with no mean skill."[36] The hill villages of Madras are also surrounded by terraced fields running along the sides of the valleys. The Coorg system of terraced cultivation takes place, we are told, "in the narrower valleys near the Ghats, where the ground is terraced with considerable

[33] Semple, p. 359.

[34] Herbertson, *op. cit.*, p. 113, quoting from Macqueen, "Through Persia in a side-saddle."

[35] Sarat Chundra Roy. "The Mundas and their country." Calcutta, 1912, p. 390.

[36] Gomme, *op. cit.*, quoting from Campbell, "Wild tribes of Khondistan."

pains, the lower and broader fields having a rivulet running through them, and these terraced up along the sides being chiefly dependent upon the rainfall."[37]

Terraced cultivation is not found in Chittagong, but it is present in Assam among the Meitheis, Kachari and Khasi.[38] Some irrigation is found among the Garo but it is mostly in the hands of Rabhas and Kochs.[39] Some of the Naga villages have irrigated terraces but unfortunately our information is not as definite as could be wished. The Angami Naga are described by Hunter as cultivating in terraces. "The terraces are constructed with wonderful care and skill in the valleys and on the hill-sides, ascending the latter for upwards of 1,000 feet, each little field having its own retaining wall of stone 5 or 6 feet high. Water is brought round for long distances in channels cut with beautiful accuracy. The soil in the terraces is manured."[40]

The Karen of Burma have terraces, each with walls of stone 5 or 6 feet high.[41] Terraced irrigation is found in Burma and the Shan states.[42]

The Batak of Sumatra have irrigated terraces but they are surpassed by the people of Nias. "And yet the Bataks do not represent the highest point attained; this is found in the remote little-visited Nias Archipelago."[43] Terraced irrigation is carried on to a great degree in Java, Madura, Bali, Lombok, and Sumbawa.[44] Wallace,

[37] Gomme, pp. 96-7 quoting from Shortt, "Hill ranges of southern India." Richter, Manual of Coorg.

[38] T. C. Hodson, "The Meitheis;" S. Engle, "The Kacharis;" P. Gurdon, "The Khasis."

[39] A. Playfair, "The Garos."

[40] Gomme, p. 98, quoting from *Jour. Roy. Anth. Inst.*, III., p. 478; XI., p. 62. Shortt, "Hill Tribes of Southern India," V., p. 65.

[41] F. Colquhon, "Amongst the Shans," p. 65.

[42] Ratzel, III., pp. 18-19.

[43] *Ibid*, I., p. 428.

[44] Semple, p. 456.

speaking of Lombok says, "Soon after passing Mataram the country began gradually to rise in gentle undulations, swelling occasionally into low hills towards the two mountainous tracts in the northern and southern parts of the island. It was now that I first obtained an adequate idea of one of the most wonderful systems of cultivation in the world, equalling all that is related of Chinese industry, and as far as I know surpassing in the labour that has been bestowed upon it any tract of equal extent in the most civilised countries of Europe. I rode through this strange garden utterly amazed, and hardly able to realise the fact, that in this remote and little known island, from which all Europeans, except a few traders at the port, are jealously excluded, many hundreds of square miles of irregularly undulating country have been so skilfully terraced and levelled, and so permeated by artificial channels, that every portion of it can be irrigated and dried at pleasure. Ascending as the slope of the ground is more or less rapid, each terraced plot consists in some places of many acres, in others of a few square yards . . . . In some places the ditches were dry, in others little streams crossed our road and were distributed over lands about to be sown or planted. The banks which bordered every terrace rose regularly in horizontal lines above each other; sometimes rounding an abrupt knoll and looking like a fortification, or sweeping round some deep hollow and forming on a gigantic scale the seats of an amphitheatre. Every brook and rivulet had been diverted from its bed, and instead of flowing along the lowest ground were to be found crossing our road half-way up an ascent, yet bordered by ancient trees and moss-grown stones so as to have all the appearance of a natural channel, and bearing testimony to the remote period at which the work had been done."[45]

[45] A. R. Wallace, "The Malay Archipelago," 3rd Edit., 1890, p. 126.

Irrigation is found in Sumba, and among the Dusum and coast people of Borneo. Also in central Celebes in,[46] the Sadang district and among the mountain group of the Toradja. Terraced irrigation is also found among the Bontoc, Infugao and Igorot of northern Luzon in the Philippines. The cultivation is on an immense scale, the terraces rising for thousands of feet up the sides of the mountains. Terraced irrigation is also found in Formosa and Japan.[47]

Miss Semple tells us that "the islands of Melanesia show generally fenced fields, terrace farming on mountain sides, irrigation canals, fertilised soils, well trimmed shade trees, and beautiful flower gardens."[48] Irrigated taro gardens are found in the Pelews and in Micronesia.[49] Irrigated terraces are reported in New Britain, New Guinea, the Solomons and the New Hebrides.[50] Dr. Haddon tells me that irrigation in British New Guinea is confined to the Massim District, but that drainage canals are made in the Fly river district "and perhaps elsewhere in the west." He says that "the irrigation in the east is for taro, and very elaborate irrigation works have been made a long time ago which are still kept up." Near Wamira, Bartle Bay, is an aqueduct about 60 feet long over a gully 30 feet deep, "a very fine piece of work." (Newton. In far New Guinea, pp. 123-4.)

Terraced cultivation is found in the d'entrecasteaux islands, and in Aurora.[51] Mr. A. M. Hocart tells me that "terraced irrigation (for taro always) occurs on a large

[46] Grubauer, "Unter Kopfjagern in Central Celebes." Leipzig, 1913. A. Kruyt and N. Adriani, "De Bare'e-spree kende Toradja's." 's Gravenhage, 1912.

[47] Jenks, "The Bontoc Igorot," pp. 88-9.

[48] Semple, p. 455.

[49] Ratzel, I., p. 254.

[50] Semple, p. 456; Ratzel, I., p. 255.

[51] Ratzel, I., p. 256.

scale in Nduke (on the maps Kulambangara) near New Georgia. The terraces were banked up with stones." Dr. Rivers tells me that terraced irrigation is found in the northern part of Santo in the New Hebrides.

An immense amount of terraced irrigation is found in New Caledonia. Glaumont speaks of huge works for taro cultivation consisting of terraces with stone and clay walls, thus having the effect of steps on the sides of the hills. "The valley of Téné was the bottom of a basin, and the mountains which surrounded it were the sides; the spectator at the centre enjoying the same coup d'oeil as if he were in the middle of a Roman circus." [52]

According to the information of Mr. Hocart, irrigated terraces in Fiji are "almost, if not quite confined to the islands as opposed to Viti Levu. It must be noted that in Viti Levu they can plant taro in dry land on the slopes owing to the damp and possibly the soil. They cannot in the islands, except Vanua Lava. . . . Irrigation was used for taro in Hawaii. . . . Terraces do not occur in Tonga unless it may be in Kao and Tofua, for the simple reason that the islands are flat and have no streams. I have seen none in Rotuma: they plant in dry land."

In the Marquesas, "Dans toutes les vallées on peut trouver des séries de gradins, de plates-formes plus ou moins larges, plus ou moins longues, selons les indications de la pente du terrein." These terraces have stone supporting walls, and they have canals for their irrigation.[53]

Fenced fields, terraces and irrigation works are found in the lesser Paumotus and in Easter Island.[54]

[52] Glaumont, "La culte de l'igaune et du taro en nouvelle-Caledonie." *L'anthropologie*, VIII.

[53] Dr. Toutain, "Notes sur les Constructions et Monuments des Marquesas." *L'Anthropologie*, VIII., p. 542.

[54] Ratzel, I., p. 254.

Our survey has thus led us right across the Pacific, and has established a chain from Britain to Easter Island, hardly any of the links of which are missing. It will now be our task to examine the American continent, for there terraced irrigation has been practised on an immense scale.

Irrigation and terraced cultivation were very widely practised in Peru. Mr. Enoch speaking of the terraces in the Andes says :—" These *andenes*, or one time cultivated terraces, are a striking feature of the Andes. . . . I have journeyed among these interminable slopes in so many parts of Peru, and marked the vestiges of cultivation on the sides of these profound and interminable valleys, where only scattered Indian hamlets and mouldering ruins exist to-day. . . . Nothing has more strongly impressed me in the long periods spent in those elevated regions than the evidences of the intensive way in which the soil was cultivated by the early Peruvians. Sitting astride our mules on some high ridge as the sunset shadows fall athwart those little known valleys of the great Cordilleras, we may mark how the declining light touches the irregularities of the slopes, giving a singular rippled or chequered appearance. This effect is caused by the innumerable terraces or andenes, the small fields, one above the other up the precipitous hill sides, fashioned in a way such as must be seen to be believed.

" The *andenes* are formed by the method of excavating the soil on the upper side and embanking it on the lower, the earthwork thus levelled being surrounded on three sides by rough retaining walls, slightly battered, as is the case of all stone work of the Inca periods. Above the first *anden* a second was made, followed by another, and so on until the whole mountain side was covered, like a gigantic flight of stairs. In some districts every hill-top

is or has been so covered, and the terraces must have numbered millions. The lowest of these terraces are naturally the longest, in conformity with the usual slope of a hill, and they diminish in size as they go upwards, ascending thousands of feet often, from the level of plain and stream up to where they are hidden in clouds and mists. In some cases on the steep ravines or semi-precipitous slopes the top terraces are of a size such as give room only for two or three rows of maize, so industrious were the people and so highly was land considered. Moreover they were served by irrigation channels, and these . . . were at times many miles in length."[55]

"Further south on this coast-zone of Peru I encountered remains of long aqueducts, a line traceable for eighty miles along the hill slopes."[56]

Terraces are also found in Ecuador, but it is not said whether they were irrigation terraces. "On many slopes the terraces are one below the other, resembling an enormous flight of huge steps."[57]

Spence says, "It was in works of irrigation, however, that the race (of the Incas) exhibited its greatest engineering genius. In the valley of Nasca the Incas cut deep trenches to reinforce the irrigating power of a small river, and carried the system high up into the mountains, in order that the rainfall coming therefrom might be conducted into the needful channel. Lower down the valley the main watercourse is deflected into many branches which irrigate each estate by feeding the small surface streams. The system adequately serves the fifteen estates of Nasca to-day! Another high level canal for the irrigation of pasture-lands was led for more than a

[55] C. R. Enoch, "The Secret of the Pacific," pp. 180-1.

[56] *Ibid*, p. 187.

[57] M. H. Saville, "Contributions to South American Archaeology. The Antiquities of Manati, Ecuador." New York, 1907, I., p. 22.

hundred and fifty miles along the eastern slope of the Cordillera."[58]

The Maya and Nahara peoples of Honduras and Mexico practised irrigation.[59] And the Aztecs had irrigation works upon an immense scale.[60]

Bancroft speaks of a huge stone aqueduct and reservoir at Tezco Zinco,[61] and he states that Mexico City had stone aqueducts and reservoirs.[62] "The garden at Iztapalapan was divided into four squares, each traversed by shaded walks meandering among fruit trees, blossoming hedges, and borders of sweet herbs. In the centre of the garden was an immense reservoir, four hundred paces square, and fed by navigable canals."[63]

Fewkes reports irrigation in the lake regions of the Haitian provinces of Xaragua, Yaquino, Bainoa, and Caiabo.[64] Authorities report traces of irrigation in Cuba.[65] Terraced irrigation is found in New Mexico, Western Texas, Arizona, and in East California among the Zŭni.[66]

For example, in Verde Valley, Arizona, in Clear Creek, stones are arranged so as to include rectangular areas which are irrigated.[67] In the "Handbook of American

[58] Myths of Mexico and Peru." London, 1913, p. 273.

[59] Bancroft, "The Native Races of the Pacific States of North America," London, 1875, II., pp. 349, 718.

[60] *Ibid*, IV., pp. 619, 632, 635, 668-70, 676.

[61] *Ibid*, II., p. 569.

[62] *Ibid*, II., p. 565.

[63] *Ibid*, II., p. 575.

[64] J. W. Fewkes, "The Aborigines of Porto Rico and Neighbouring Islands." *Smiths. Rep.*, XXV., 1903-4, p. 50.

[65] *Ibid*, p. 51.

[66] F. H. Cushing, "Pueblo Pottery and Zŭni culture-growth." *Smiths. Rep.*, 4, p. 477; *Smiths. Rep.*, XXIII., 1901-2. XII., *et seq.*; F. W. Hodge, Prehistoric Irrigation in Aurina, America," *Anthropologist*, VI.; F. Russell, *Smiths. Rep.*, XXVI., 1908, pp. 86 *et seq.*

[67] Fewkes, "Expedition to Arizona." 1895. *Smiths. Rep.*, XVII., 1895-6, p. 538. C. Mindeleff. "Aboriginal remains in Verde Valley, Arizona." *Smiths. Rep.*, XIII., 1891-2, pp. 238, 244.

Indians" it is said that irrigation is found in the south-west States on the Rio Grande and its tributaries. Irrigation canals, dams and reservoirs are found in the valleys of the Gila and its tributaries in South Arizona.[68] The Pima Indians of the Gila river irrigate by means of conduits and ditches leading from the river into reservoirs.[69] The same author states that traces of ancient irrigating canals and ditches are to be found in New Mexico.[70] In Arizona, especially in the Gila bottom, irrigation is found. The Moqui Indians on the Rio Grande had reservoirs lined with masonry, "the face of the cliff had been ingeniously converted into terraces. These were faced with neat masonry, and contained gardens, each surrounded with a raised edge so as to retain water upon the surface. Pipes for the reservoirs permitted them at any time to be irrigated. . . . . A long flight of stone steps, with sharp turns that could easily be defended, was built into the face of the precipice, and led from the upper reservoir to the foot of the town."[71] Again it is said that "The walls of the terraces and reservoirs were of partially dressed stone, well and strongly built, and the irrigating pipes conveniently arranged."[72] Fewkes says in one place, "Students of South-western Archæology are familiar with rows of stones marking off the surface of the land in rectangles of great regularity. Some of these lines of stones extend for several hundred feet. Similar sites are found in the San Simon valley. "They may be regarded as the walls of terraced gardens, so placed as to divide different patches of cultivated soil, and to prevent this soil from being washed down to the plain below. "Very

[68] *Op. cit.*, I., p. 619—*et seq.*
[69] Bancroft, I., p. 539.
[70] Bancroft, IV., p. 619.
[71] Bancroft, IV., p. 668.
[72] *Ibid*, p. 670.

extensive irrigated terraced gardens are to be seen not far from San Jose. "It would seem from their distribution that not only irrigation ditches watered the valley of Pueblo Viejo, but also that water was in some way carried up the hillsides, so that land now barren was in ancient times cultivated by the people of this region." The use of terraced gardens still survives among the Hopi Indians.[73]

A certain form of agriculture about which I know nothing further than is recorded in the following extract was once practised in the valleys of the Ohio and Mississippi. It seems to bear some relationship to that described in the west and south-west of these regions. "It is pretty well established that since the time of the Mound Builders and prior to the advent of the Indians, a race known as the "villagers" occupied certain districts in this country and made the "garden beds" found in northern Indiana, lower Missouri, and in the valleys of the Grand River and St. Joseph's, Michigan. These beds exist in the richest soil in that part of the country. Some of the lines of the plots are rectangular and parallel, others are semi-circular and variously curved, forming avenues, differently grouped and disposed. The ridges are low, averaging four feet in width, and the depth of the walk between them is about six inches. They cover from ten to one hundred acres, and sometimes embrace even three hundred acres. The beds are laid out with great order and symmetry, and have certain peculiar features that belong to no recognised system of horticulture. These beds are entirely different from the system of field culture as practised by the Indians, and no similar remains are connected with the enclosures of Ohio."[74]

[73] J. W. Fewkes, "Two Summer's work in Pueblo ruins." *Smiths. Rep.*, XXII., 1900-1, pp. 176-8.

[74] J. P. Maclean, "The Mound Builders," Cincinnati, 1885, p. 131.

[Upon Mr. Perry's map I have added some spots around the head waters of the Yenesei to indicate that agriculture with irrigation was carried on there in ancient times (see E. H. Minns' "Scythians and Greeks," Cambridge, 1913, p. 246). The discussion of the interesting type of culture associated with this practice in Siberia must be reserved for some future occasion, for its consideration involves some of the most complex problems in the history of the Bronze Age. Mr. Perry's map at once suggests the source of the Yenesei culture.

F. W. Christian ("The Caroline Islands," London, 1899) gives an excellent account of the ancient terraces in Yap, where so many instructive relics of the stone-using people and their legends still persist.

Since the map has been printed my colleague, Professor Calder, has called my attention to the remarkable remains of extensive terraced-cultivation and irrigation at Kara Dagh in Asia Minor (see Sir William Ramsay and Miss Gertrude Bell's, "The Thousand and One Churches," London, 1909, p. 31 *et seq.*).

In his previous communication[1] to the Society, Mr. Perry called attention to the intimate association between the geographical distribution of ancient mines and megalithic monuments, and incidentally referred to the connection between these things and terraced-cultivation and irrigation. I have met with a curious passage, quoted in a memoir on "Commerce in Prehistoric Times," by Miss Buckland,[2] which seems to throw some light upon this matter.

Referring to the introduction of metals and megalithic architecture into Ireland she says :—"This change

[1] "The Relationship between the Geographical Distribution of Megalithic Monuments and Ancient Mines," *Manchester Memoirs*, Vol. 60, Part I.

[2] *Journ. Anthr. Inst.*, Vol. XIV., 1885, p. 8.

we can only suppose to have been caused by foreign influence, and for this foreign influence we must look to countries already acquainted with the use of metal, and practising that mode of architecture, and those religious rites which they would seem to have introduced among the Firbolgs, whose name Warner translates as "*creeping or cave men*," although Keating ("History of Ireland") gives a legend that they were the descendants of the first Greek colonists . . . . and he derives the term Firbolg from Fir, signifying *men*, and Bolg, a *bag*, from the leathern bags they had been compelled to wear, to carry clay dug from pits to the top of hills, to make a soil upon the rocks for cultivation. I do not know what traces of the terraced cultivation, so much in use in Southern Europe, are to be found in Ireland."

This is surely a remarkable confirmation of an association of practices at which Mr. Perry had arrived inductively from other evidence derived from the Far East.

He has not attempted to discuss the origin of terraced-irrigation.

From time immemorial a system of cultivation and irrigation, which presents many striking analogies to the terraced-method, was in practice in Babylonia and Egypt; but we have no certain knowledge as to which people was the inventor of it.

There can be little doubt that terraced-cultivation and irrigation originated, probably in Southern Arabia, as a modification of the more ancient Egyptian and Sumerian method of cultivating and irrigating the banks of their respective rivers.

The ancient Egyptian records contain the earliest references to terraced-cultivation; for in the account inscribed in Queen Hatshepsut's temple at Deir el Bahari

(*circa* 1500 B.C.), it is recorded that the God Amon commanded the queen to search out the myrrh-terraces of Punt, and that the temple was built as a reproduction in Thebes of these terraces, in which were planted the myrrh trees brought back by the expedition (see Breasted's "History of Egypt," London, 1906, p. 274). If, as most archæologists now maintain, Punt was not in Southern Arabia, but on the African coast, this record at Deir el Bahari calls for a further addition (S) to Mr. Perry's map, or alternatively, is another argument for those who would locate Punt in Arabia.

The geographical distribution tells its own story.

G. Elliot Smith.]

Manchester Memoirs, Vol. lx. (1916), *No.* 7.

VII. The Geographical Distribution of the Shell-Purple Industry.

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Introduction.

Among the many curious and ornamental uses to which shell-fish have been applied, one of the most striking and interesting is undoubtedly their employment for the production of the famous dye known as "Tyrian purple."

Much has been written concerning this dye and the subject has been discussed in its economical and philosophical aspects by numerous writers.

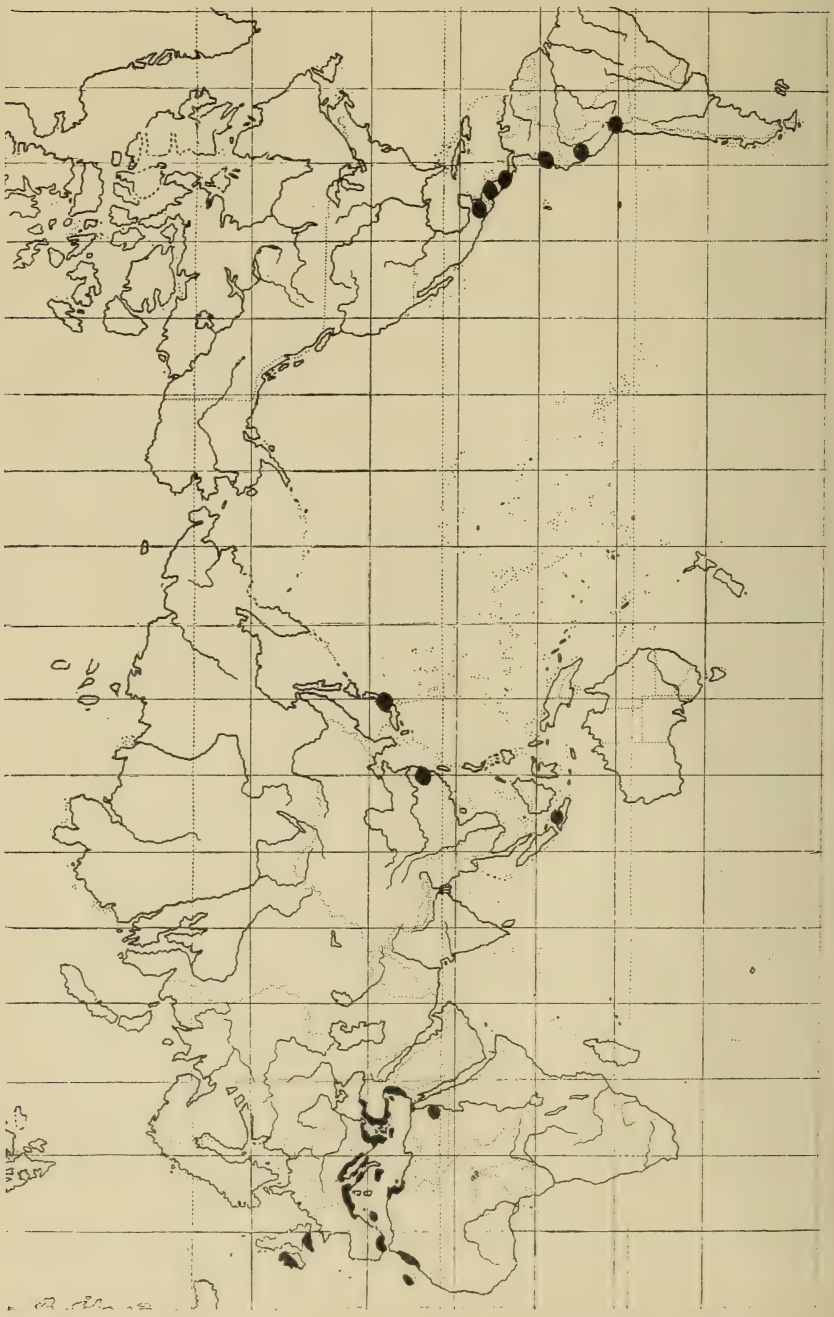
By far the best and most comprehensive summary of the various contributions to our knowledge of the subject is the article on Purpura by Maurice Besnier, in Daremberg and Saglio's "Dictionnaire des Antiquités."[1] The bibliography quoted by this author is astonishing and serves to show how extensively the subject has been treated by writers of different nationalities.

But Besnier, and the authors he quotes, deal only with the classical area or the Mediterranean. The aim of the present paper is to trace out, as far as it is possible to do so, the geographical distribution of this interesting industry; not only in the Old, but also in the New World.

Many data relating to the use of this shell-purple are to be found in the historical records, but in some cases its

[1] Vol. IV.—1., Paris.

May 22nd, 1916.



Map showing the Distribution of the Shell-Purple Industry.

former presence in a particular area can only be inferred from the finding of broken and crushed shells, which serve equally definitely to distinguish certain ancient stations for the extraction of the purple.

From the works of ancient writers, especially Aristotle and Pliny, we learn that this famous colouring matter was in great demand among the people of the Mediterranean region. It was this purple dye, in fact, which was largely responsible for giving to the textile fabrics of the Phœnicians their world-wide reputation.

Both Aristotle and Pliny give the details of the process by which it was procured from the shell-fish. They tell us that the precious liquid was obtained from a transparent branching vessel behind the neck of the animal and that at first the material was of the colour and consistency of thick cream. When the shells were small, many of them were bruised together in a mortar; but when large, the animal was taken out entire, usually by breaking a hole in the side of the shell, and the sac containing the colouring matter was taken out, either while the animal was still alive, or as soon as possible after death, as otherwise the quality of the dye was impaired. This was mixed with a quantity of salt, about 20 ozs. to every 100 pounds of juice, to keep it from putrefying. Three days, and no more, were allowed for the steeping process, and the liquid was then set to boil in vessels of tin or lead. The vessel was placed at the end of a long funnel, which communicated with the furnace, and while boiling the liquid was frequently skimmed to remove impurities. The proportions were about 500 pounds of material to every hundred amphoræ of water. About the tenth day, as a rule, the whole contents of the cauldron were in a liquified condition, and a fleece, freed from all grease, was then plunged in by way of a trial; but until such time as the colour was found to

be satisfactory, the liquid was still kept on the boil. The wool was left to soak for five hours, and then after being carded, was thrown in again, until it had fully imbibed the colour.[2]

A very curious fact concerning this dye, which was noted also to some extent by the ancients, is the transformation through which it passes on exposure to sunlight. The fluid is at first colourless, but on exposure to the action of the sun it becomes of a bright yellow, speedily turns to a pale green, and continues to change imperceptibly until it assumes a bluish cast and then a purple red. These changes of colour, which are faster or slower according to the intensity of the sun's light, are accompanied by the production of a disagreeable foetid odour, similar to that of essence of garlic.

This peculiarity was well known to the ancients and is referred to by Pliny. It was probably the cause of the extravagant use of perfumes by the wearers of "the purple" in classical times.

THE SOURCES OF THE PURPLE.

The vague descriptions of the Greek and Latin writers has led to much discussion as to the exact species of shell-fish used in the manufacture of the dye.

Pliny speaks of two kinds that produce the purple colour. The smaller "fish," he tells us, was called the "buccinum," from its resemblance to the conch by which the sound of the buccinus or trumpet is produced; the other "fish" was known as the "purpura," or purple, and was studded with points up to the very apex, differing in this respect from the first kind.

The earliest attempt to discover the source of the ancient purple seems to have been made by William Cole,

[2] Pliny, "Nat. Hist.," ix., ch. 62.

of Bristol, in 1686,[3] who conducted experiments on shell-fish (*Purpura lapillus*) found on the shores of Somerset-shire, South Wales, and Ireland, in the course of which he discovered the curious photogenetic properties of the colour. These experiments were continued by other observers, including Reaumur,[4] du Hamel,[5] Deshayes,[6] and Lacaze-Duthiers.[7] The general concensus of opinion on the question is that the 'purpura' of Pliny is the *Murex trunculus*, or the *M. branderis*, of modern conchologists, while the 'buccinum' of the Roman naturalist is probably the *Purpura hæmastoma*, all three species being common to the Mediterranean shores. The *Purpura lapillus*, so abundant on the shores of Europe generally, is also likely to have been employed in the production of the inferior sort of purple.

The *Murex*-shell is almost constantly in evidence as a design upon Tyrian coins from A.D. 112 onwards. The shell here is quite distinct from the "so-called" *Murex* of pre-Alexandrine coins (*circa* 450-400 B.C.). The latter is not a *Murex* at all, but is more like a *Triton*, or trumpet-shell; and the same shell appears on the coins of Byblus (*c.* 350 B.C.) and of Tarentum (*c.* 400-330 B.C.). The *Murex* of the imperial coins of Trye (A.D. 112 on) is distinctly like *Murex branderis*, one of the chief purple-yielding shells.

Whether the design of the *Murex* (and so-called *Murex*) on these coins had primarily any connection with

[3] *Phil. Trans. Roy. Soc., Lond.*, xv., pp. 278—86, and plate.

[4] *Mém de l'Acad. des Sciences*, 1711, pp. 168-199 (Reaumur also accidentally discovered that the egg-capsules of *Purpura* afforded the dye in greater abundance, and with less trouble, than the animal itself).

[5] *Ibid.* 1736, pp. 49-68.

[6] "Mollusques de la Méditerranée," in "l' Expéd. Scient. de Morée, Section des Sciences physiques," iii., Paris, 1832, pp. 189-192.

[7] *Proc. Roy. Soc. Lond.*, x., 1860, pp, 579-584; also *Ann. des Sci. Nat. Zool.*, xii., 1859, pp. 5-84, and plate.

the purple-trade of Tyre is doubtful, though this has been suggested by leading authorities.

Judging from the associated symbols, particularly those of the serpent, palm-tree, "mundane egg," etc., it seems to have a greater affinity with serpent and phallic worship.

At least two species of *Murex*, and one of *Purpura*, appear to have been employed by the Phœnicians in the manufacture of Tyrian purple. Lortet records that in the vicinity of Sidon, great banks, a hundred yards long and several yards thick, occur composed entirely of broken shells of *Murex trunculus*,[8] while at Tyre, according to Tristram,[9] large quantities of crushed and broken shells of *Murex branderis*, have been met with. Tyre, which is reputed to have produced the best purple in Asia, is referred to by Strabo[10] as unpleasant, as a place of residence, owing to the great number of its dyeworks.

The Tyrian method of dyeing differed slightly from that narrated by Pliny, for the dyers merely made a bath of the liquid in which the wool to be treated was steeped for a certain time. It was then taken out and thrown into another boiler, which contained an extract from the *Buccinum*, or Trumpet-fish, only. This process—the so-called "purpurea dibapha"—gave to the stuffs a richer and more vivid hue. Wool submitted to this double process was so highly esteemed that, in the reign of Augustus, each pound sold for one thousand Roman denarii, or about thirty-six pounds sterling. We need not wonder at this enormous price, considering the tedious nature of the process and the small amount of dye produced from each shell-fish. For fifty pounds of wool, the

[8] L. Lortet, "La Syrie d'aujourd'hui," Paris, 1883, p. 102.

[9] H. B. Tristram, "The Land of Israel," 1882, p. 48. See also Besnier, *op. cit.*, p. 770, for other references, and the use of *Purpura hæmastoma*.

[10] Strabo, xvi., c. 11, p. 756.

ancients used no less than two hundred pounds of the liquid of the *Buccinum* and one hundred pounds of that of the *Purpura*.[11]

The best purple was stated by the ancients to be exceedingly durable; and when Alexander took possession of Susa, he found among the treasures of Darius, 5,000 talents in weight of purple cloth, from Hermione in the Peloponnesus, which had been laid up there for 180 years, and yet retained all its freshness and brilliance of colour.[12]

The purple-bordered prætextæ of Servius Tullius, with which the statue of Fortune dedicated by him, was covered, lasted until the death of Sejanus; and it is a remarkable fact, that, during a period of 560 years, they had never changed colour.[13]

The real Tyrian purple and purple-stuffs were essentially articles of luxury, varying in price according to times and quality.

They were always costly and vied in value even with gold itself. Consequently we find them reserved for the hangings of temples, or employed for the robes of priests and kings. Moses, it is recorded, used purple stuffs for the works of the tabernacle, as well as for the habits of the high priest; and among the presents which the Israelites made to Gideon the Scriptures mention purple raiment that belonged to the kings of Midian.[14] The Babylonians are said to have devoted this purple to the dress of their idols, and Tertullian speaks of its use among the ancient kings of Egypt and Babylonia.[15] It was considered a noble and sacred colour by the ancients and emblematic of the power of the gods, an idea which is

[11] Mary Roberts, "A Popular History of the Mollusca," 1851, p. 120.

[12] Plutarch, *Alex.*, p. 36.

[13] Pliny, "N. H.," viii., ch. 74.

[14] "Judges," 8, 26.

[15] Tertull, *De idol*, p. 18.

explained by Besnier by the resemblance of the purple to the colour of blood, the principle of life.[16]

But this explanation is not convincing. The mere price of the purple made the use of it a privilege of kings and priests.

By the Greeks and Romans purple was regarded as the peculiar insignia of royalty or of official distinction, such as magistrates, military officials, priests, etc. It also played an important rôle in certain of their legends.

Its use was forbidden to the common people, and laws were made inflicting severe penalties, and even death itself, upon all who should presume to wear it under the dignity of an emperor.

Though the Tyrian purple served principally as a dye for cloth, generally of wool, but sometimes of silk, it was also employed as a paint for the parchments of precious books written in letters of gold, and as a colour for inks.[17] It had a prominent place also among the toilet requisites of the Romans and was applied in place of rouge to the cheeks and lips.[18]

Attention might also be called here to the use of the purple on the sails of vessels in the earliest times. These sails were of rich colours, with floral and other designs, and were in early use in Egypt, and seem to have been bought by the Tyrians.[19] The hem or border of these sails was coloured according to the rank or station of the owner. It is mentioned by Atticus that the sails of the large ship of Ptolemy Philopater were of fine linen, ornamented with a purple border. And we find the ship of Antony and

[16] Besnier, *op. cit.*, p. 777.

[17] *Ibid.* p. 778.

[18] Athenæus, xiii., ch. 8, p. 604. See also Besnier, *op. cit.*, p. 778, for other references.

[19] Ezekiel, 27, 7 . . . "Fine linen, with embroidered work from Egypt, was that which thou spreadest forth to be thy sails."

Cleopatra at the battle of Actium, distinguished from the rest of the fleet by having purple sails—a distinction which is said to have been at that time the peculiar privilege of the admiral's vessel.[20]

The Centres of Production and Distribution of the Purple Industry.

The Phœnicians have been accredited with the invention of this famous purple as well as with that of glass, but modern investigators are depriving these 'maritime pedlars' of much of their former prestige. Glass has been shown to have been first made by the Early Egyptians many centuries before the probable date of the Phœnician occupation of the Mediterranean coast, and the credit of the invention of shell-purple has now been transferred to the Minoans of Crete. R. C. Bosanquet, in his note on "An Early Purple-fishery"[21] tells us that "Leuke, the 'White Isle' (modern Kouphonisi), off the south-east coast of Crete, was an important fishing-station in antiquity. The tithes levied on the catch of fish and of purple-shell mentioned in an inscription of about 350 B.C., must have been very profitable, for the possession of the island was the subject of a long and bitter dispute among three neighbouring cities."

This island was explored in 1903 by C. T. Currelly and R. C. Bosanquet, and "among sand-hills on the north shore they found a bank of shells, some whole but mostly crushed, of *Murex trunculus*, which is known to have been used in the manufacture of the purple dye."

"Scattered through the heap were fragments of pottery, and of a stratile bowl which marked it as not only præ-Hellenic but præ-Phœnician. Further digging

[20] J. Napier, "Manufacturing Arts in Ancient Times," 1874, pp. 287—8.

[21] *Brit. Ass. Rept.*, 1903, p. 817.

within a few yards of the heap brought to light characteristic Cretan vases of the Kamáres type, and the foundations of a house."

"The evidence shows that the extraction of the purple-juice was practised in Crete at least as early as 1600 B.C."[22]

Though the Phœnicians were not the original discoverers of the famous dye, they were largely instrumental in spreading the knowledge of the art among the people with whom they traded. Their two great centres of manufacture were Sidon and Tyre and the large quantities of broken shells around these cities testify to the importance and extent of the industry.

The purple of Tyre was greatly estimated and considered the best in Asia.[23] The dyeworks of this city endured for many centuries until the end of the Roman Empire. The imperial manufacture of purple at Tyre is mentioned in the reign of Diocletian before 300 A.D.,[24] and in 383 A.D. the fabrication of purple of superior quality became a state monopoly.[25]

Among other towns of Phœnicia cited as manufactories of purple stuffs are Sarepta, Caesarea, Neapolis, Lydda, and the port of Doros.[26] The inhabitants of the island of Cyprus also carried on this industry. The Phœnicians likewise introduced the knowledge into Egypt and a private manufactory is said to have existed in the town of This, near Abydos, in the 7th cent. A.D. But it is not clear how the purple could have been made so far from the sea.

[22] Bosanquet, *op. cit.*

[23] Pliny, "N.H." ix., ch. 60.

[24] Besnier, quoting Euseb, *Hist. Eccles.*, vii., p. 32.

[25] *Ibid.* quoting *Cod. Just.*, iv., 40, p. 1.

[26] Besnier, *op. cit.*, p. 774. Being unable to obtain access to many of the works quoted by Besnier, I give these and other references on his authority.

The search for the purple-bearing shell-fish seems to have been one of the motives which lead the Phœnicians to explore areas further afield than their own immediate shores. The Ægean and the shores of Asia Minor were visited by these ancient mariners, and important fisheries were established at several places both here and elsewhere around the Mediterranean.

Many of their stations are made known to us by ancient writers, but the evidence of the existence of others rests upon the discoveries of heaps of broken shells.

In Asia Minor fisheries for purple-shells are cited by Aristotle[27] on the coasts of Caria, and the Edict of Diocletian mentions the purple cloths of Miletus.[28] There were purple dyeworks also at Phocæa in Lydia,[29] and at Hierapolis in Phrygia.[30] In Troas shells were fished at Lectum and at Sigeum,[31] and one of the islands of the Propontis (Sea of Marmora) was known as Porphyrione.[32] Vitruvius mentions the purple of Pontus.[33] In the Ægean Sea the islands noted for purple were Rhodes,[34] Nisyros (formerly Porphyris),[35] Coos, Amorgos and Chios.[36] According to Herodotus, Itanus, at the eastern extremity

[27] Aristotle, *Hist. An.*, v., 15, 3. In the time of Homer the women of Caria trafficked in purple (*Il.* iv., 141).

[28] *Edict. Diocl.*, 24, 6 & 7.

[29] Ovid, *Met.*, vi., 9. Thyatira in Lydia was celebrated for its purple-dyeing (*cf.* Homer, *Il.* iv., 141); at Philippi a seller of purple from Thyatira was converted by St. Paul (*Acts*, 16, 14).

[30] *cf.* Besnier, *op. cit.*, p. 775.

[31] Aristotle, *op. cit.*

[32] Pliny, "N. H.," v., ch. 44.

[33] Vitruvius, vii., 13.

[34] *Ibid.*

[35] Pliny, "N. H.," v., ch. 36.

[36] *cf.* Besnier, *op. cit.*, p. 775. (At Coos, cloths were probably dyed with Kermes-coccus).

of Crete, was also an ancient Phœnician station and probably a factory for the purple trade.[37]

In Thessalia purple was manufactured at Melibœa, and a purple-establishment existed at Thessalonica in Macedonia.[38]

In Greece proper the two most important centres of the industry were the coast of Laconia and the Gulf of Corinth. The purple of Laconia was considered the best in Europe.[39] Large heaps of *Murex branderis* are reported by Tristram on this coast.[40] From the island of Cythera the Phœnicians despatched to the east and the west the celebrated "Laconian purples."[41] On the north shore of the Gulf of Corinth, in Phocis, the purple-shells were so abundant that half the population of Bulis was occupied solely in their capture.[42]

Among other Grecian places famous for the purple industry, may be mentioned the coast of Argolis, with the port of Hermione, where the purple stuffs of Darius were prepared ;[43] the east coast of Eubæa ; Eretria and Styra in the same island ; and Anthedon in Bœotia.[44]

In the western Mediterranean, Tarentum, the modern Otranto, was a most important station for purple from an early date. Hardouin tells us that in his time there were still to be seen the remains of ancient dyeing-houses, and that vast heaps of the shells of *Murex* had been discovered there.[45] Aufrère, in 1789, describes a hill called Monte

[37] Herod, iv., p. 151.

[38] *cf.* Besnier, *op. cit.*, p. 775.

[39] Pliny, "N. H.," ix., ch. 60.

[40] H. B. Tristram, *op. cit.*, p. 48 footnote.

[41] *cf.* Besnier, *op. cit.*, p. 775.

[42] *Ibid.*

[43] Plutarch, *Alex.*, 36.

[44] *cf.* Besnier, *op. cit.*, p. 775.

[45] *cf.* footnote in Bostock & Riley's "Pliny, N. H." (vol. ii., p. 447).

Testaceo, behind the Alcantarine Convent at Tarento, consisting chiefly of the shells of *Murex branderis*.[46]

The purple of the Adriatic port of Ancona is cited by Silius Italicus. Dalmatia, Istria, Venetia and Sicily, Baiæ and Aquinum on the west coast of Italy, were also centres of the industry in Roman times.[47] Fischer, in his "Manuel de Conchyliologie,"[48] refers to the discovery at Pompeii of heaps of *Purpura* in the neighbourhood of many dyeworks.

Liguria provides us with interesting evidence of an early search for purple. In two caves in this region, the cave of Pollera and Caverna delle Arene Candide, both said to be of Neolithic age, Don Morelli found the broken shells of *Purpura hæmastoma*. Mosso,[49] in referring to these discoveries, overlooks their true significance, and states that this mollusc has never been found in Italy, but is very common along the West African shore. On this account he suggests that the cave shells represent objects brought by early mariners returning from Africa as votive offerings for escape from the dangers of the sea. Regarding the distribution of the species in question, Mosso is somewhat at fault; it is very widely distributed in the Mediterranean, occurring on the coasts of Provence, Corsica, Sardinia, Sicily, and elsewhere. There is no reason, therefore, to assume that the cave shells came from any great distance. That they had been collected locally for the extraction of the purple dye seems evident from their broken condition, and in this connection it is of interest also to note that in the same caves *Triton* shells were found which had every appearance of having been

[46] Lovell, "Edible British Molusca," 1884, p. 205, quoting Aufrère's "Travels."

[47] *cf.* Besnier, *op. cit.*, p. 775.

[48] 1887, p. 14.

[49] Mosso, "Dawn of Mediterranean Civilisation," 1910, p. 269.

used as trumpets.[50] The importance of this fact cannot be overlooked when one considers the intimate relationship in Crete, and other places, between the use of shell-purple for dyeing and the employment of conch-shells for trumpets. A further point is worthy of mention here, and that is the discovery of a pearl-shell (*Meleagrina margaritifera*), a native of Eastern Seas, on hut foundations near Reggio Emilia, N. Italy.[51] The coincidence of the occurrence of all three objects—shell-purple, conch-shell trumpets, and pearl-shell—in North Italy, is most remarkable, and seems to indicate definite contact with the advanced cultures of the Eastern Mediterranean.

Regarding the geographical distribution of the purple industry further west, we find that Vitruvius makes allusion to the purple of Gaul,[52] while Strabo refers to that of southern Spain, (Turdetania, near Carteia),[53] and to the introduction of purple to the Balearic Islands by the Phœnicians.[54] In these islands *Purpura hæmastoma* is still used by the fishermen of Minorca to mark their linen ; *Murex trunculus* is also known to them as yielding a fixed and permanent colour.[55]

With regard to the purple of Spain, Duckworth, in his "Cave Explorations at Gibraltar,"[56] mentions the discovery of specimens of *Purpura hæmastoma* with the apical portion fractured in a curious manner, and suggests, on

[50] Mosso, *op. cit.*, p. 363, quoting Morelli, "Resti organici rinvenuti nella Caverna delle Arene Candide," Genova, 1901, p. 111.

[51] Mosso, *op. cit.*, p. 269, quoting Colini, *Atti della Società romana d'Antropologia*, x., 1904.

[52] Vitruvius, vii., p. 13.

[53] Strabo, iii., 145. Carteia lay east of Gades (Cadiz) and was a colony planted by the Tyrians about B.C. 1130, *cf.* Rawlinson, "History of Phœnicia," 1889, p. 419.

[54] Strabo, iii., 167, *cf.* Besnier, *op. cit.*, p. 775.

[55] Lacaze-Duthiers, *Proc. Roy. Soc.*, x., 1860, p. 583.

[56] *Journ. Roy. Anthrop. Inst.*, xli., 1911, p. 363, and pl. xl. fig. 3.

the authority of the Rev. A. H. Cooke, that the mollusc was used for the preparation of its distinctive product, the "Tyrian Purple."

In Africa, the island of Meninx (now Jerba) in the Gulf of Cabes, was famed for its purple, as well as parts of Gætulia that border on the ocean.[57] The port of Zuchis, on the mainland, close to Meninx, also contained factories for purple dyeing.[58] Juba II., King of Mauritania, is said to have established a manufactory of this dye, known as "Gætulian Purple" in the Purpurariæ, or "Purple Islands" (probably the Madeira group).[59]

In the British Isles the art of purple dyeing from shell-fish seems to have been known from very early times. That it dates from pre-historic times in Ireland seems evident from the discoveries made in 1895 by R. Standen and his co-workers of "Purpura-mounds" associated with "Kitchen-middens" of *Patella vulgata*, *Littorina littorea*, etc., at Portnafeadog (or Dogs Bay), Connemara, West of Ireland.

In his paper on the subject[60] the author states that the shells of *Purpura lapillus* in the "Purpura-mounds" had all been broken in a peculiar manner. In each case the apical whorls were smashed, leaving the lower whorl with mouth intact, and in some cases portions of the second and third whorls remaining along with the columella. The broken *Purpura* shells were present in enormous quantities and one large heap measured 55 yards in length, 15 yards across the broad end, and 3 yards across the narrow end. Two hundred specimens were picked up from one square foot.

Heaps of the shells of the same species in a broken

[57] Pliny, "N.H.," ix., ch. 60.
[58] Strabo, xvii., 835.
[59] Pliny, "N.H.," vi., ch. 36.
[60] *Journal of Conchology*, viii., 1896, p. 187.

condition and associated with other edible kinds, bones of animals, stone implements, and flint flakes, have since been noticed by several observers round the Donegal coast in sites similar to those at Dogs Bay.

Regarding the Dogs Bay discovery, F. J. Bigger, one of the 1895 party, writes :[61] "Shells of this species, either whole or broken, had seldom been observed among other remains in sandhills, and certainly never in any quantity ; but here there was a large heap, all broken, which seemed to have the same connection with the sites as the shells of the other species."

Enquires were made in the neighbourhood as to whether the *Purpura* was now used for any purpose, but not even the oldest inhabitant could recollect hearing of its being used as food, or bait, or in any way whatever.

Large quantities of broken shells of *Purpura lapillus*, together with rounded pebbles of quartz, large enough to break them, have also been found by the Rev. R. Ashington Bullen in "Kitchen-middens," close to the Late-Celtic cemetery, at Harlyn Bay, North Cornwall.[62]

These discoveries of broken *Purpura* shells in the British Isles have led to much discussion as to the possibility of their use as food like the other associated species. This question, however, has been ably dealt with by Standen and Bigger, who point out the unsuitability of this species either for food or bait, whereas the associated species, *Patella* and *Littorina*, may be used for either purpose. They suggest, therefore, that the *Purpura* shells may have been broken in order to extract the animal for the rich purple it affords. A similar suggestion is put forward by the Rev. R. Ashington Bullen.[63]

[61] *Proc. Roy. Irish Academy*, 3rd Ser., v., 1899, p. 437.

[62] *Proc. Malac. Soc.*, v., 1902, p. 185, and *Trans. S. Eastern Union of Sci. Soc.*, 1903.

[63] *Ibid.*

Apart from the evidence afforded by the Mediterranean instances of broken shells, this interpretation receives strong support from the interesting statement made by Lenormant and Chevallier in dealing with the purple industry of the ancients. According to these authors the Phœnicians "also procured from the British Isles a dark shade, called 'black purple,' but it has not yet been ascertained with certainty what species produced it."[64]

Further evidence of the antiquity of purple in Ireland is furnished by Wood-Martin in his "Lake Dwellings of Ireland."[65] On p. 104 of this work the author tells us that the MS. Book of Ballymote contains an ancient Irish poem, which states: "It was Tigearnmas who first established in Ireland the art of dyeing cloth of purple, and many colours."

This King—variously given as Tighernmas and Tiernmas—is alleged to have reigned about 1000 B.C., and "was the first that smelted gold in Ireland."[66]

We have many instances of the survival of this purple industry in the British Isles. Johnston[67] tells us that the Venerable Bede, who wrote in the eighth century, mentions the art as known in his time, and he was familiar with the beauty and permanency of the colour.[68] The same fact is mentioned by Richard of Cirencester,[69] and also in a translation of Higden's "Polichronicon" made in the year 1387.[70]

Purple shell-fish were largely employed from the 16th

[64] "Manual of Ancient History of the East," London, 1870, ii., p. 214.

[65] Dublin and London, 1886.

[66] Kinahan, "Geology of Ireland," 1878, p. 340.

[67] Johnston, "Introduction to Conchology," 1850, p. 72.

[68] "Hist. Eccles. Gent. Ang.," lib., c. l.

[69] "Desc. of Britain," 28.

[70] Book i., ch. 38 of "Bretayn."

to 18th centuries for marking linen in Somersetshire, Cornwall and other parts of England, as well as in Scotland, France, Norway and other parts of Europe.[71]

Purple robes were in frequent use in Ireland during ancient times. In the tale of Eithne and King Cormac, quoted by Whitley Stokes in his introduction to the Irish "Tripartite Life of St. Patrick," i., p. xxxviii., fifty maidens in purple mantles are mentioned. In the "Book of Rights," p. 65, cloaks trimmed with purple are noticed; at p. 87, the King of Ara is said to be entitled to six purple mantles from the King of Erie; at p. 147, the stipend of the King of Ui Breasail includes three purple cloaks. We are told that Medb presented Ferdiad with a girsat cocra or purple waist scarf to induce him to fight Cuchulaind.[72]

Apart from its use in the dyeing of fabrics, we find, in Miss Robert's work,[73] some interesting particulars as to the employment of Tyrian purple, in Britain and elsewhere, in dyeing parchments, or vellum. This was done for the purpose of rendering still more splendid the manuscripts, which were adorned with gold and silver letters. This magnificent and expensive style of writing on purple vellum was appropriated to Biblical manuscripts, and the libraries of princes. As examples of this class of work we have the book of the Gospels, which Louis the Pious gave to the monastery of St. Medard, at Soissons, now in the royal library of France, and the Book of Prayers, bound in ivory, and studded with gems, formerly belonging to Charles the Bald, but now in the celebrated Colbertine Library.

Similar manuscripts were also occasionally made in

[71] See papers by Cole, Reaumur, du Hamel, Deshayes, and Lacaze-Duthiers, l. c.

[72] F. J. Bigger, *Proc. Roy. Irish Acad.*, 3rd ser., iii., 1896, p. 730.

[73] Roberts, *op. cit.*, pp. 123-4.

England. The famous Wilfred ordered a copy of the four Gospels to be written for the church of Ripon, in letters of the purest gold, upon leaves of parchment, purpled in the ground, and variously coloured on the surface.

The Gregorian Bible, presented by a monkish missionary and his companions to the first Christian church erected at Canterbury, was also of a similar description.

Eastward of the Mediterranean we find several indications and curious survivals of this ancient purple industry.

According to Johnston,[74] the Chinese make use of a similar dye. The extreme conservatism of Chinese tastes suggests that the art is no recent importation amongst them. Bancroft[75] also gives an interesting quotation regarding the use of shell-purple by the Chinese settlers in the Malay region. He tells us that "Mr. John Nicuhoff relates that 'abundance of purple snails are found in the islands over against Batavia. They are boiled and eaten by the Chinese, who have a way of polishing the shells, and prick out of the middle of the snail a certain purple-coloured substance which they use in colouring and making red ink.'"

That the purple was appreciated and sought for by the ancient inhabitants of Japan is implied from the discovery of certain broken shells in their "Kitchen-middens." Professor Edward S. Morse, in his paper on "Shell Mounds of Omori,"[76] tells us that along with such species as *Fusus inconstans*, *Hemifusus tuba*, *Eburna japonica*, etc., the shells of *Rapana bezoar* were exceedingly abundant in the mounds and of large size with massive

[74] Johnston, *op. cit.*, p. 74.

[75] Bancroft, "Philosophy of Permanent Colours," i., 1794, pp. 93—4.

[76] *Memoirs of the Science Dept., Univ. of Tokio*, Japan, vol. i., pt. i., No. 2539, 1879.

shell. Many of the specimens of this species had a portion of the body whorl broken away "as if for the purpose of more conveniently extracting the animal." The same species is recorded from the Okadaira Shell Mound at Hitachi by J. Jijima and C. Sasaki,[77] who also call attention to the fact of the specimens having almost always an irregular opening in their body whorl as if made for facilitating the extraction of the animal.

Why the shells of this particular species should be broken and not the others is remarkable. The idea that such a procedure was solely to facilitate the extraction of the animal for food purposes does not appear to be conclusive. A far greater significance is attached to such an occurrence when one considers that *Rapana bezoar* belongs to the purple-bearing family, *Muricidæ*, and is closely allied to *Purpura*. It is not improbable, therefore, that the object in breaking the shells was to obtain purple for dyeing purposes. That these ancient people were not wholly ignorant of textiles is evidenced by the occurrence of spindle-whorls associated with the pottery and shells of the mounds.

In the New World we have ample evidence of the practice of this ancient industry at several places in Central America, especially in the 17th and 18th centuries. Here the species employed is *Purpura patula*, which is plentiful in the West Indies, and on rocks between high and low tide levels on both the Atlantic and Pacific coasts of Central America. It resembles the *Purpura hæmastoma* of the Mediterranean, one of the species used by the ancient Tyrian dyers, and which, as previously mentioned, is still used by the Minorcan fishermen to mark their linen.[78]

[77] *Ibid.*, Appendix: No. 2542, 1882.

[78] See Lacaze-Duthiers, "Nat. Hist. of Purple of Ancients," *Proc. Roy. Soc. London*, x., 1860, p. 583.

D'Argenville, in his "Conchyliologie (1742, p. 181), states that the "Conque Persique" is made use of both in Panama and Guatemala for dyeing purposes and, on that account, is called "Poupre de Panama." The "Conque Persique" (*Purpura persica*) inhabits the Indian Ocean, and was distinguished from the *Purpura patula* of the Pacific coast by Brugière in 1789 and Lamarck in 1803.

In 1744, Don Antonio de Ulloa saw at S. Elena, in what is now Ecuador, and also at Nicoya (Costa Rica), purple colour produced from sea-shells. He describes the process in his "Physical and Historical Account of Southern and North-Eastern America" as follows: "On the coasts belonging to the province of Guayaquil the finest purple is found. The animals from which it is derived are contained in shells, about the size of walnuts, and live on rocks washed by the sea. They contain a juice or humour, which is taken out, and yields the true purple. . . . . Cotton, thread, and other delicate materials are dyed with it. It gives a lively and durable colour, which does not lose its lustre by frequent washings, but is rather improved thereby, and does not fade through long-continued use and exposure. Near the port of Nicoya in the province of Guatemala the same kind of shell-fish is found, and is used for dyeing cotton. . . . . Various processes are employed for extracting the juice or humour. Some kill the animal. They take it out of its shell, and, having laid it on the back of the hand, press and squeeze it with a knife from the head to the tail, and then separate the expressed juice, the rest of the animal matter being thrown away. They treat in this way a number of animals until they have a sufficient quantity of juice. They then draw through the thread which they wish to dye, and no more is required. . . . . Others express the juice without killing the animal. They do

not take it entirely out of the shell, but only press it so as to cause a certain quantity to be ejected, with which the threads are dyed. The shells are then laid again on the stones from which they were taken. They recover, and after some time give a fresh quantity of juice, but not so much as the first time."[79]

Thomas Gage,[80] an earlier observer, gives an account as follows: "About Chira, Golfo de Salinas, and Nicoya, there are some farms of Spaniards, few and very small Indian Townes, who are all like slaves employed by the Alcalde Maior, to make him a kind of thred called Pita [agave fibre], which is a very rich commodity in Spain, especially of that colour wherewith it is dyed in these parts of Nicoya, which is a purple colour; for the which the Indians are here much charged to work about the Sea shore, and there to finde out certain shels wherewith they make this purple dye."

Of the process of purple dyeing as practised in more recent times by the natives of Nicaragua, Squier[81] gives us the following account: "Some of the cotton fabrics manufactured by the Indians are very durable and woven in tasteful figures of various colours. The colour most valued is the Tyrian purple, obtained from the murex shell-fish, which is found upon the Pacific Coast of Nicaragua. This colour is produced of any desirable depth and tone, and is permanent; unaffected alike by exposure to the sun and to the action of alkalies. The process of dyeing the thread illustrates the patient assi-

[79] Translation quoted by Dr. E. Schunck in "Notes on the Purple of the Ancients," *Journ. Chem. Soc.*, xxxvii., 1880, *Trans.*, pp. 613-614.

[80] "The English-American, his Travail by Sea and Land: etc.," London, 1648 (quoted by MacCurdy, *Mem. Conn. Acad. Arts & Sciences*, iii., New Haven, March, 1911, p. 160).

[81] "Nicaragua, its People, Scenery, Monuments, etc.," 1852, vol. i., p. 286.

duity of the Indians. It is taken to the sea-side, when a sufficient number of shells are collected, which being dried from the sea water, the work is commenced. Each shell is taken up singly, and a slight pressure upon the valve which closes its mouth [operculum] forces out a few drops of the colouring fluid, which is then almost destitute of colour. In this each thread is dipped singly, and after absorbing enough of the precious fluid, is carefully drawn out between the thumb and finger, and laid aside to dry. Whole days and nights are spent in this tedious process, until the work is completed. At first the thread is of a dull blue colour, but upon exposure to the atmosphere acquires the desired tint. The fish is not destroyed by the operation but is returned to the sea, when it lays in a new stock of colouring matter for a future occasion."

In connection with the Nicoya industry, the observations of C. V. Hartman[82] are interesting. On one of his recent expeditions to the Pacific Coast of Costa Rica, he visited Guanacosta, where he saw an Indian woman from Chiriqui wading in the water in search of *Purpura*. She would put the shell to her mouth and blow into it, causing the snail to discharge a greenish yellow fluid, which she applied to white cotton thread. The fluid in drying turns to purple.

An even more interesting account of the existence of purple dyeing in the New World is that recently published by Zelia Nuttall, viz., "A curious survival in Mexico of the use of the Purpura shell-fish for dyeing."[83] In this paper an excellent description is given of the dyeing of cotton thread for the manufacture of purple skirts worn by the women of Tehuantepec. In the spring the cotton

[82] See Mac Curdy, *op. cit.*, p. 160, quoting Hartman.

[83] Putnam Anniversary Volume, 1909, pp. 368-384.

skeins are taken in boats by the fishermen along the coast northward, where suitable habitats of the *caracol* or sea-snail are visited. "Slipping a skein over his left wrist, the fisherman wrenches one sea-snail after another from the wet rocks, blows on it, causing it to exude the dye-stuff, which resembles a milky froth, and then dabs the cotton thread with numerous shells in succession, until it is thoroughly saturated. When each shell had yielded its small supply of liquid dye, some fisherman pressed it to the rock and waited until it adhered thereto, but others laid the shell in a pool. When treated thus the same shells yielded a second, though diminished supply, when the rocks were visited on the return journey" (pp. 369-370).

The late Professor von Martens, in a paper read before the Berlin Anthropological Society on October 22nd, 1898,[84] deals very thoroughly with the subject of purple dyeing in Central America. In this valuable contribution he discusses the evidence as to whether the employment of the shell-fish for dyeing purposes was an independent and precolumbian invention of the Indians, or was introduced by the Spaniards. He rightly concludes that it was practised in America in pre-historic times.

Through Professor Edward Seler, Professor von Martens obtained information of the Tehuantepec industry, and was shown not only a purple skirt, which the Zapotecan women wear only on special occasions and which but few can afford, but also kerchiefs with purple stripes such as are worn by the Huave Indians, to the south-west of Tehuantepec.

Professor von Martens found, on examining some of

[84] *Verhand. Berliner Gesell. für Anthrop. Ethnol. u. Urgesch.*, 1898, pp. 482-6.

the only precolumbian textiles in existence, those of Peru, preserved in the Royal Ethnographical Museum in Berlin, a garment and some bands with narrow stripes, the colour of which is identical with that of the Huave kerchiefs. He also noticed the same in textiles from Chimbote, Peru (Bolivar collection).[85]

In further support of his conclusion that the dye of the *Purpura* shell was used in America in precolumbian times, Professor von Martens refers to the use, alongside of each other and in the New and Old World alike, of two other shell products, viz., the conch-shell trumpets and pearls. The interesting data concerning these two products, and the evidence they afford in the spread of certain elements of culture, will be given in future communications. It will be sufficient here to point out that Professor von Martens' conclusion is strikingly confirmed by the further evidence produced by Mrs. Nuttall.[86] She tells us that in the ancient Mexican Codex named after her, a beautiful purple paint is profusely used. This Codex "contains pictures of no fewer than thirteen women of rank wearing purple skirts, and five with capes and jackets of the same colour. In addition, forty-six chieftains are figured with short, fringed, rounded purple waist-cloths, and there are also three examples of the use of a close-fitting purple cap." Priests and other personages are also represented whose bodies, and sometimes faces, are painted purple, and throughout the Codex the same colour appears in combination with others in ornamental designs and figures.

Mrs. Nuttall points out further that "the shade of the purple paint used is identical with that of the purpura dye, and until it is demonstrated to us that the native

[85] Von Martens, *op. cit.*, p. 485.

[86] Nuttall, *op. cit.*, pp. 380-1.

artists obtained this colour from some now unknown mineral or vegetal dye, it may be assumed that they also used the purpura dye in preparing their paint and in depicting personages with body paint and garments dyed by means of the same shell-fish."[87]

The employment of purple paint in ancient Mexican manuscripts is decidedly interesting and recalls the use made of this famous colour for dyeing the ecclesiastical parchments in Europe during early times. In like manner the purple facial-painting of the Aztecs, as demonstrated by their manuscripts, is a curious parallel to the employment of purple for the cheeks and lips in Roman times.

Some further important evidence of the use of shell-fish in dyeing in precolumbian times has lately been furnished by the discovery of broken *Purpura* shells in Inca graves in North Chile. L. E. Adams, in his "Conchological Notes from Chile and Brazil,"[88] mentions the occurrence of broken shells of *Purpura* in a "kitchen midden" on the steep mountain-side at Pisagua. These were discovered, along with other marine shells, in the course of road improvements, the road in question being found to traverse an Inca burying ground. Adams states: "Several human skeletons were lying on or just below the surface, all in the characteristic doubled-up attitude; they had been buried wrapped up in a coarse grass matting. None of the skulls were perfect, the upper and lower jaws were all missing, as if the excavators had taken them to study the dentition."

"In addition to human remains, were skulls of some large species of dolphin, skulls of sea-lions (? *Otaria jubata*), the rib of a small whale, and dogs both large and

[87] Nuttall, *op. cit.*, p. 381.

[88] *Journ. of Conchology*, xiv., 1915, p. 349.

small; to one of the latter, which was enveloped in matting, the reddish hair was adhering."

It is suggested by Adams, and by H. B. Preston who identified the various shells, that the *Purpura* were the refuse of food, the shells having probably been split open to obtain the animal whole. The breaking of the *Purpura*, however, seems to me to possess a greater significance.

Judging from the occurrence in the Old World of similar heaps of shells broken in the same peculiar manner in order to obtain the purple product, it is not at all unreasonable to assume that here we have an indication that the Incas were cognizant of the art of purple dyeing by means of shell-fish. This discovery, therefore, is most valuable, as it at once disposes of any further doubt concerning the precolumbian use of shell-fish for dyeing purposes, and, moreover, provides us with interesting information as to the precise source of the purple colour in the beautifully preserved textiles of Peru.

As already pointed out, this purple industry is closely associated, both in the Old and in the New World, with the appreciation of pearls and the use of the artificially devised conch-shell trumpet. Each of these cultural elements had their origin in the Eastern Mediterranean. Stations for the purple industry, as we have seen, were established by the early Mediterranean mariners in several places in the Old World. In addition, we find that an intimate relationship existed between this art and skill in weaving, as well as the mining, working and trafficking in metals, such as gold, silver and copper.

In the New World the purple industry is associated with similar pursuits.

As Mrs. Nuttall points out, "we find that, in precolumbian times, the Zapotecs, whose descendants still use the purpura, were famed as miners, as workers in

copper, gold and silver, as weavers, and as enterprising traders who travelled far and wide, trafficking with these products and the cocoa-bean."[89]

Similarly, the ancient Chiriquians of the Panamic region, whose descendants, the Guaymis, still go in search of the *Purpura* shells, were metal workers in gold, copper and their alloys.

That all the foregoing, in addition to other associated elements of culture, could have developed independently in the Old and in the New World is inconceivable. In Mexico, Central and South America, the aborigines unanimously disclaim their independent discovery of all arts and industries and assign their introduction to strangers of superior culture from distant and unknown parts.[90]

As Mrs. Nuttall justly concludes, "it seems almost easier to believe that certain elements of an ancient European culture were at one time, and perhaps once only, actually transmitted by the traditional small band of . . . Mediterranean sea-farers, than to explain how, under totally different conditions of race and climate, the identical ideas and customs should have arisen."[91]

The peculiar and distinctive character of the shell-purple industry is in itself sufficient justification for this conclusion, as it is altogether unlikely that different people could have adopted so remarkable a custom, along with identical methods of extracting the precious purple matter from shell-fish.

CONCLUDING REMARKS.

In glancing over the facts quoted in this paper it will be at once apparent that many gaps exist in the geographical distribution of this remarkable industry.

[89] Nuttall, *op. cit.*, p. 381.
[90] *Ibid.* pp. 382-3.
[91] *Ibid.* pp. 383-4.

These lacunæ, however, are probably more apparent than real, and are due rather to lack of precise information, than to an entire absence of the art in certain places.

I have been unable so far to trace any indication of this industry in the numerous islands of the Pacific.[92]

Judging from the presence in these islands of other associated elements of culture, such as shell-trumpets and pearls, acquired by direct or indirect contact with the Eastern Mediterranean, it seems possible that the art of dyeing by means of shell-fish also spread in this direction. Various circumstances, however, may have prevented the adoption of so curious a custom.

It must be remembered that particular kinds of shell-fish were necessary for the production of the purple, and much would depend on the presence of one or other of these forms in the seas round the islands of the Pacific. *Murex* and *Purpura* certainly occur in their neighbourhood, but they are totally unlike the purple-yielding shell-fish of the Mediterranean—a fact that may have led to their being disregarded by the bearers of the particular culture. It is only when we reach the American coast that we find a form of shell-fish analogous to that used by Tyrian dyers of ancient times.

[92] The reference to its use in New Zealand, given in *Manch. Mem.*, Vol. 60, 1915, No. 1, p. 36, is founded on a misunderstanding.

Manchester Memoirs, Vol. lx. (1916), *No.* 8.

VIII. Shell-Trumpets and their Distribution in the Old and New World.

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Manchester Museum.

Hon. Librarian of the Conchological Society of Great Britain and Ireland.

The wide-spread use of shells as horns or trumpets is of very ancient origin.

The Latin word *Buccina*, or *Buccinum*, a trumpet, was indiscriminately applied by the ancients to almost every kind of spiral univalve shell. Amongst the Greeks the large *Triton nodiferus*, Lam., was the trumpet used in land—and sea—fights, as well as for setting the watch and calling together assemblies of the people.[1]

Triton, Neptune's trumpeter, is generally depicted with a large conch shell in his hand, with which it is fabled he convened the river deities around their monarch. It is wreathed, like those called *Sikanos*, or Sea-horn, common to India, Africa, and the Mediterranean, and still used as trumpets for blowing alarms or giving signals.[2]

Itanian coins (*circa* 200-67 B.C.) have the figure of a sea-god or triton carrying a trident and blowing a conch-shell.[3]

Triton holding a conch with both hands and blowing into it is also seen on the coins of Agrigentum, Sicily (before B.C. 406.)[4]

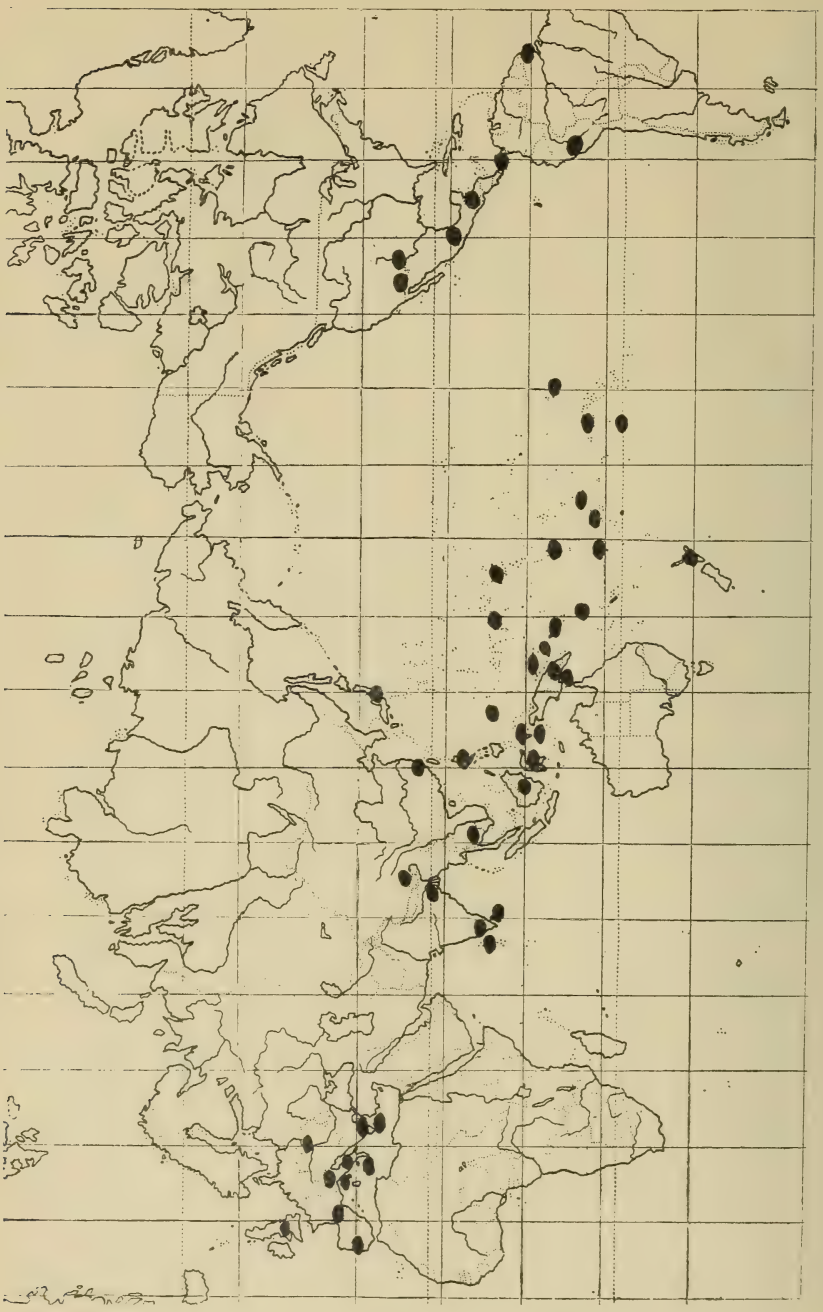
[1] Jeffreys, "Brit. Conch.," iv., 1867, p. 284.

[2] Mary Roberts, "Popular History of the Mollusca," 1851, p. 97.

[3] B.V. Head, "Hist. Numorum," 1887, p. 398.

[4] *Ibid.* p. 106; and "B.M. Cat. Greek Coins: Sicily," 1876, p. 15.

May 22nd, 1916.



Map showing the Distribution of Shell-Trumpets.

Note: Evidence of their use in Florida and the Sandwich Islands arrived too late for insertion.

Pliny tells us that a deputation of persons from Olisipo [Lisbon], that had been sent for the purpose, brought word to the Emperor Tiberius that a triton had been both seen and heard in a certain cavern, blowing a conch-shell, and of the form under which they are usually represented.[5] And one of the Scholiasts on Homer says, that before the discovery of the brazen trumpet by the Tyrrhenians, the conch-shell was in general use for that purpose.[6]

The larger species of *Buccinum* is still used by Italian herdsmen in directing their cattle. It is also common in North Wales, Staffordshire, Lithuania, and Muscovy, where they are also applied to pastoral purposes.[7] At Casamicciola, in the Island of Ischia, conch shell trumpets are sounded to scare away thieves and birds from the vineyards and gardens.[8] Sicilian fishermen use *Triton nodiferus* as a trumpet, and Vérany tells us that at Nice this shell, with a hole at the top, serves as a trumpet for the fishermen and country people, and that the braying noise produced by it renders this unmusical instrument indispensible for the old-fashioned charivari, which he describes as a deafening serenade to signalize the marriages of widows and ill-assorted couples.[9] A. Mosso relates that the *Triton* is still sounded in church at Piedmont, and that during the services in Holy Week at Chieri, when the choir was singing the psalms, and a table was struck with sticks during the so-called tenebræ of the sepulchre, the sacristan gave him a *Triton* shell to

[5] Pliny, "Nat. Hist.," ix., ch. 4. (Bohn's Ed., vol. ii., p. 362).

[6] *Ibid.* (footnote by Bostock & Riley).

[7] Roberts, *op. cit.*, p. 97, and Lovell, "Edible Brit. Moll," 1884, p. 194.

[8] Lovell, *op. cit.*, p. 194, quoting Dr. Wm. Russell, "Memories of Ischia," *Nineteenth Century*, Sept., 1883.

[9] Jeffreys, *op. cit.*, iv., 1867, p. 303.

sound.[10] Issel also relates that during the services of Holy Week in the Cathedral of Genoa, the *Triton nodiferus* used to be sounded.[11]

In his paper on "Purple Dyeing in Central America,"[12] Professor von Martens refers to the survival of the use of shell-trumpets at the present day in certain localities in southern France, Elba, Corsica, and Sicily, for the summoning of fishermen and field labourers.

In the 18th century the Corsican militia, under Paoli, employed them instead of drums and trumpets.[13]

Triton shells are still in common use in Crete, especially among the village guards, as a means of raising an alarm or calling for help.[14]

As in the case of Shell-purple,[15] the island of Crete figures very prominently in the early use of shell trumpets.

Mariani has published a Minoan seal on which a woman is sounding the shell of a *Triton* before the sacred horns of an altar.[16] This seal, which was found in the Idaean cave, is also described and figured by A. J. Evans in his "Mycenaean Tree and Pillar Cult."[17] "Here," he tells us, "a female votary is seen blowing a conch-shell or triton before an altar of the usual Mycenaean shape. Above the altar is seen a group of three trees, apparently cypresses, and immediately in front of them the 'horns of consecration.' To the right of the altar is a rayed symbol, to the left is apparently another altar base, with a conical

[10] Mosso, "The Dawn of Mediterranean Civilization," 1910, p. 365.

[11] *Ibid.* p. 365, quoting A. Issel, "Revista Ligure di Scienze, Lettere ed Arti," Genova, 1908, p. 19.

[12] *Verhand, Berlin. Gess. Anthrop. Ethnol. und Urges.*, 1898, p. 485.

[13] Von Martens, *op. cit.*, p. 485, quoting Boswell, "Description of Corsica," 1768, p. 183.

[14] A. J. Evans, *Journ. Hellenic Studies*, xxi., 1901, p. 142.

[15] See my earlier article.

[16] L. Mariani, "*Monumenti Antici*," vi., 1895, p. 178, f. 12.

[17] A. J. Evans, *op. cit.*, p. 142, f. 25.

excrescence, and behind the votary another tree. From this gem it appears that the conch-shell trumpet performed a ritual function in summoning the divinity."

At Palaikastro, and elsewhere, real *Triton* shells were found which had been used for purposes of cult.[18]

R. C. Bosanquet points out in his "Excavations at Palaikastro, I." that "the *Triton*-shell occurs as frequently in early deposits in Crete as it does in Mycenaean ornament—for the so-called *Murex* on the later pottery is only a degradation of the *Triton*."[19]

A. J. Evans, in his account of the Knossos Excavations, 1903,[20] illustrates a Minoan clay seal impression, on which two *Triton*-shells are represented. He also records the discovery of an alabaster vase in the shape of a *Triton*-shell.[21] Miniature clay models of the same conch-shell, with remains of a little terra-cotta Sanctuary, were also found in an early basement on the East side of the Palace.[22]

This Early Minoan rite spread in the Mediterranean region, for eighteen unbroken specimens of the same shell, *Triton nodiferus*, were found by Don Morelli in the Caverna delle Arene Candide, besides two hundred broken ones; and as they all had the apex removed it can be concluded that they were sounded like trumpets.[23] Other *Triton* shells were found in the Caverna dei Balzi Rosso, in the Cave of Galuzzo and the Cave of Pollera.[24]

[18] *Ann. Brit. Sch. Athens*, viii., (1901-2), pp. 32, 89, 244, 296, 305, 308; ix., (1902-3), pp. 275, 291, 312, and 335; x., (1903-4), pp. 197, and 202.

[19] *Ibid.* viii., (1901-2), p. 296.

[20] *Ibid.* ix., (1902-3), p. 56, f. 34.

[21] *Ibid.* ix., (1902-3), p. 36.

[22] *Ibid.* viii., (1901-2), p. 32.

[23] N. Morelli, "Resti organici rinvenuti nella Caverna delle Arene Candide," Geneva, 1901, p. 111.

[24] Mosso, *op. cit.*, 1910, p. 363.

In another Ligurian cave, the Grotta di Bergeggi, a *Murex trunculus* pierced at the apex was found.[25]

In excavating the Minoan Sanctuary of Cannatello, near Girgenti, Mosso also found pieces of the *Triton*.[26]

In speaking of the *Triton* shells found in the neolithic caves of Liguria (see above), Mosso states that they are too numerous for them to have been used for signals, but "the fact that they are found associated with human bones gives reason to suppose that even in neolithic times these shells were sounded with a religious signification, as we see on the Minoan seals of Crete."[27]

Amongst the various species of shells used as trumpets, the chank-shell (*Turbinella pyrum*) is of special interest from its intimate connection with the religion of Hindus and Buddhists.

In a previous paper on "The Aztec Moon-cult and its relation to the Chank-cult of India,"[28] I have already referred to the association of the chank with the Hindu god, Vishnu, and his many incarnations.

The whole subject of Hindu chank-cult has been recently treated in a most admirable manner by James Hornell in "The Sacred Chank of India,"[29] and much of the following information is derived from his excellent work.

In Hindu temple worship, Hornell tells us "the chank fulfils important service. The ordinary and sinistral forms are both employed whenever the temple possesses them. The former is used in the menial duty of summoning the god's attention, announcing the commencement of the principal rites, as well as in calling the

[25] T. E. Peet, "The Stone and Bronze Ages in Italy," 1909, p. 54.
[26] Mosso, *op. cit.*, 1910, p. 364.
[27] *Ibid.* p. 363.
[28] *Manch. Memoirs* (*Lit. and Phil. Soc.*), vol. 60, pt. ii., 1916.
[29] Madras Fisheries Publication, No. 7, 1914.

devout to worship ; such are among the general explanations given for its employment, but some ethnologists hold that the innate and primitive significance of the use of the blowing chank in temple worship is to scare away hostile and evil-working spirits. This is a reasonable belief as there is little or no doubt that the chank was used originally as a horn or trumpet by tribes holding animistic beliefs prior to the development of the Brahman religion, which appears to have adopted the use of the chank in religious ceremonies together with many other rites from the devil-fearing tribes who gradually came into the fold of the new and higher religious belief." [30]

In Bengal it is customary to keep blowing-chanks in the houses of the better class people for use in family worship, and during eclipses and earthquakes these shells are blown continuously till the eclipse or earthquake is over.[31]

Unlike the sinistral shells, which are usually mounted in handsomely decorated golden settings, the temple conchs are usually without any ornamentation, but the Udipi temple owns one very beautifully mounted in brass, and this is sounded whenever the god (Krishna) is carried in procession in the temple car.[32]

Chanks used as wind instruments are chosen of as large size as possible, and the only preparation they require is to have the apex knocked off.

Apart from their actual use in temple ritual, chank-trumpets are employed in connection with harvest rites, marriage and funeral ceremonies, and in various other ways in different parts of India. It is an essential part of the professional paraphernalia used by certain castes of religious medicants. " The Dasari," Hornell tells us, " is

[30] Hornell, *op. cit.*, pp. 134-5.
[31] *Ibid.* p. 135.
[32] *Ibid.* pl. xvii., fig. 1.

often seen in North Arcot and the Southern Deccan, announcing his arrival in a village by blasts on the chank shell."

In Malabar, at the ceremony of the bringing in of the first fruits, the priest comes forth from the local temple, preceded by a man blowing a conch.

Similarly in Siam, conch-shell music is employed at religious ceremonies connected with the ploughing festival. The principal figure at these ceremonies is the Minister of Agriculture, who is borne in a palanquin to the field with an escort of priests blowing loud blasts on chank shells.[33]

At weddings, among all Hindu non-Brahman castes in the districts of the south of India, the chank is blown by the barber (ambattan) particularly at or immediately after the tying of the *tali* or marriage badge round the bride's neck. In Bengal this custom of chank-blowing during weddings is even more general.

Though men are usually engaged to blow the chank at weddings, the women of the family or of the particular caste sometimes perform this duty.

A further interesting use of chank-trumpets is in connection with the rite of circumcision which survives among the Puramali nādu Kallans. This rite is carried out in a grove or plain outside the village, and the chank is blown at frequent intervals *en route* and throughout the ceremony.[34]

Throughout the Tamil country all non-Brahman castes which observe Hindu rites have the chank sounded at death ceremonies. The chank sometimes has a place in the death ceremonies of castes which are not Hinduised, as the Cherumans of Malabar and Cochin. Here the chank-trumpet is used for devil-driving.[35]

[33] Hornell, *op. cit.*, p. 144.
[34] *Ibid.* pp. 144-5.
[35] *Ibid.* pp. 148-9.

The chank is frequently employed upon native-owned plantations in South India and Ceylon to summon the workpeople to their duties.

In the Laccadive Islands it is used to call the people together in cases of emergency and public requirements.[36]

In addition to the use of the chank, *Turbinella pyrum*, as a trumpet in India, T. Wilson, in his "Prehistoric Art,"[37] mentions other trumpets made from *Cassis*, or helmet shell (called Gomukha) and from *Pterocera* (called Barataka).

Speaking of the use of shell-trumpets in Ceylon, Lovell[38] states, "According to the most ancient annals of the Cingalese, the chank-shell is sounded in one of the superior heavens of the demigods (similar to the conch-blowing tritons of Grecian mythology) in honour of Buddha, as often as the latter wanders abroad on the earth." Hornell[39] also says, "In the purer Buddhism of Ceylon the chank cult also finds place, and figures prominently among the musical instruments employed to lend eclat to the periodic procession (*perahera*) of the tooth-relic at Kandy."

In Thibet, according to the writings of travellers in that country, the call of the chank is amongst the most familiar sounds to be heard in the monasteries and temples of the Lamaistic faith. It is also the custom to sound the chank as the body of a deceased monk or nun is being conveyed from the place where death occurred.[40]

Chank-shells, especially sinistral specimens, are held in special veneration by the Chinese, and are kept in the Pagodas by the priests for use on special occasions.

[36] *Ibid.* p. 172.

[37] *Rept. U.S. Nat. Mus.* for 1896 (1898), p. 555.

[38] Lovell, *op. cit.*, p. 195.

[39] Hornell, *op. cit.*, p. 137.

[40] *Ibid.* pp. 137 and 149.

They are also blown to still the waves and ensure safe voyages. The Chinese, likewise, use a large shell, a species of *Fusus*, for their fog-horns.[41]

Both Huish[42] and Rein,[43] in their works on Japan, mention the use of *Triton*-horns in that country. Rein tells us that shells of *Triton tritonis* (Japan, Hora-gai) "were formerly employed as signal horns and provided with a brass mouthpiece to replace the tips. According to Pinto, in blowing them, riot was indicated by one blast, fire by two blasts, robbery by three, treachery by four, though they also played a part as signal horns in war, and were therefore also called Jin-gai, war mussel shells or camp snails. Their blowers were the Hora-fiu, or Hora-wo-fuku. Both these expressions for blowers of the Triton's horn have become in Japan the common designation for a person who is fond of boasting: 'Ano hito wa hora wo fuku,' he blows the Triton's horn, *i.e.*, he is bragging."

In the East Indian Archipelago and the Pacific Islands, we find many instances of the use of shells as trumpets.

In describing the wind instruments used by the tribes of Borneo, Shelford[44] relates that some Brunei Malays recently informed him that a trumpet, made by merely knocking off the top whorl of the large helmet-shell *Cassis tuberosum*, was used by them for calling their buffaloes together; their name for the trumpet was "buyong." He could hear of no other people in Borneo who employ a similar instrument.

[41] A. H. Cooke, "Mollusks," Camb. Nat. Hist., 1895, pp. 101-2.

[42] Huish, "Japan and its Art," 1893, pp. 146-7.

[43] J. J. Rein, "Japan," 1884, p. 207.

[44] R. Shelford, "Illus. Cat. Ethnog. Coll. Sarawak Museum: Pt. i., Musical Instruments." *Journ. Straits Branch Roy. Asiatic Soc.*, No. 40, June, 1904, p. 20.

Von Martens refers to the use of shell-trumpets in the Philippine Islands, in the island of Halmaheira (or Gilolo)[45] and by the Alfurs of Ceram.[46]

A fine specimen of a trumpet made from a large *Triton tritonis* has recently been shown me by Professor S. J. Hickson. It was obtained by him in the Celebes, and is perforated on the side of one of the upper whorls. It was used by the boatman who carried round the mails, and may have originally come up from the south.

In Papua, or New Guinea, *Cassis cornuta*, *Triton tritonis*, and *Ranella lampas*, are used as trumpets, having a hole drilled as a mouthpiece in one of the upper whorls.[47] In addition to the *Triton*, Moseley[48] tells that a large conical *Strombus*, perforated at the apex, not on the side, as in *Triton*, is used by the natives of Humboldt Bay. Among the musical instruments used by the natives of the Admiralty Islands are conch-shells perforated on the side as usual.[49]

The only instrument of the trumpet kind used by the Torres Straits Islanders is a giant *Fusus* [*F. proboscidiferus*, Lam.[50]], or occasionally a large *Triton*. The *Fusus* is universally employed, and, according to Haddon,[51] the mouth-hole is always lateral. It was employed for conveying signals, but now at all events is most frequently blown when the natives are sailing, especially when going fast or racing.

[45] *Zeits. für Ethnol.*, iv., 1872, p. 34, *fide* Schmeltz, "Schnecken und Muscheln im leben der völker Indonesiens und Oceaniens," Leiden, 1894.

[46] *Verhand. der Berl. Anthro. Gess.*, 1898, p. 485.

[47] A. H. Cooke, *op. cit.*, p. 99.

[48] Moseley, "Notes by a Naturalist on H.M.S. 'Challenger'," 1892, p. 378.

[49] Moseley, *op. cit.*, p. 407, also *Jour. Anthrop. Inst.*, 6, 1876-7, p. 411.

[50] Probably *Megalatrachus aruanus* (L).

[51] "Anthrop. Exped. to Torres Straits," Cambridge, iv., 1912, p. 283, and fig. 248.

There is a *Triton*-trumpet in the British Museum from the mouth of the Fly River, British New Guinea, which, according to Chalmers, is used for calling to arms and for frightening away the evil spirits of sickness from the village.[52]

W. H. R. Rivers, in his work on "The History of Melanesian Society"[53] tells us that the conch-shell is one of the objects used in Banks Islands, in the ritual of initiation into the *Sukwe*. On the initiation of a candidate into *Kwatagiav*, the conch-shell is blown five times, three long continuous blasts and two interrupted blasts. It is also used at initiation into the *Tamate liwoa*. In Torres Islands the conch is blown at ceremonies of kava drinking.[54]

From the same authority we learn that "the conch-shell exists in two forms in Melanesia, one blown by means of a circular hole in the side, and the other blown at the end. The former is that used at the *Sukwe* and in most parts of Melanesia, and this form is also in general use in Polynesia. Its occurrence in Polynesia points to its ascription either to the kava-people or to the people who interred their dead in the sitting position, and there is reason to suppose that it was of especial importance in connection with the chiefs. It may also be noted that, in Malikolo, it is used at the funerals of chiefs. This connection with chiefs both in Polynesia and southern Melanesia, suggests that it was the kava-people who brought with them the use of the conch, a conclusion in harmony with its prominence in the ritual of the Sukwe.

"In the Solomons, however, the conch is of especial importance in connection with head-hunting. It is used

[52] Haddon, *op. cit.*, p. 283.
[53] 2 vols., Cambridge, 1914.
[54] Rivers, *op. cit.*, i., pp. 64, 98, 186.

as a signal, especially in the ceremonies which accompany the return from a successful expedition, and this suggests either that it is an element of culture common to the kava- and betel-peoples, or that it was taken over by the betel-people from the earlier inhabitants.

"The only place in Melanesia where we know of the existence of the conch-shell blown at the end is Efate [New Hebrides], and its association here with a special form of totemism suggests that it is connected with a special development of the kava-culture which has been responsible for the form of totemism found in this region." [55]

In discussing the material culture of the inhabitants of the Bismarck Archipelago, Rivers further relates that "the conch made of the shell of the *Triton* is not only definitely present in New Britain and New Ireland, but it has that place in the ritual of the secret organisations which we should expect if it were introduced by the kava-people. When the members of the *Ingiet* take one of their stone images from one place to another, its approach is heralded by the sound of the conch which warns all uninitiated persons to get out of the way. When an uninitiated person hears the conch, he says, 'Here comes an image from Nakanai,' thus associating the instrument with one of the more sacred images. Another indication of the importance of the conch in the *Ingiet* is that it may be shown to an initiate in place of a stone image if one of these is not available, thus suggesting that the conch may once have formed one of the mysteries of the society, comparable with the *werewere* or *meretang* of the Banks Islands or the bullroarer of the *Matambala* and *Rukruk*." [56]

[55] *Ibid.* ii., p. 459.

[56] *Ibid.* ii., p. 535.

Zembsch, in his "Katalog No. 1 verzeichniss einer ethnographischen Sammlung aus der Südsee"[57] gives a photo of a clay figure of a god from Malikolo with a *Triton*-trumpet tied to each hand. The trumpets are perforated on the side of the spire.

In the Solomon Islands, Guppy[58] tells us that the shell-trumpets are made of large examples of both *Triton* and *Cassis*, with a hole pierced on the side of the spire.

In the island of Tanna, in the New Hebrides, shell-trumpets are blown as signals to the disease-makers, or sorcerers, to entreat them to stop plaguing their victims. "These disease-makers collected any *nahak*, or rubbish, that had belonged to anyone, such as the skin of a banana he had eaten, wrapped it in a leaf like a cigar, and burned it slowly at one end. As it burnt, the owner's illness increased; and if it was burnt to the end, he died; therefore, as soon as a man fell ill, feeling sure that some sorcerer was burning his rubbish, shell-trumpets, which can be heard for miles, are blown as a signal for the sorcerers to stop, and wait for the presents which should be sent in the morning. When a disease-maker fell ill himself, he too believed that some one was burning his rubbish, and had his shells blown for mercy."[59]

Hedley, in his "Ethnology of Funafuti,"[60] tells us that the Ellice Islanders are called together to a trial or other public ceremony by the blowing of a shell trumpet made from the large *Cassis cornuta*.

The conch-shell also ranges among the musical instru-

[57] Ethnographische Abteilung der Buchhandlung und Druckerei vormals, E. J. Brill, Leiden, 1897, pl. iii.

[58] Guppy, "The Solomon Islands, and their natives," 1887, p. 143.

[59] Lovell, *op. cit.*, 1884, p. 195, quoting Turner's "Polynesia," and Taylor's "History of Mankind," p. 128. See also G. Turner's "Samoa," etc., 1884, pp. 320-21.

[60] *Mem. Aust. Mus.*, iii., pt. 4, 1897, p. 299.

ments of the Fijians, and of the Maories of New Zealand.[61]

When Captain Wilson visited Tongataboo, in the Friendly Islands, in 1797, four large conch-shells were found on the floor of a large house sacred to the god of Bretane. These were used to alarm the country in times of danger. In these islands conch-shells were also blown at the interment of chiefs.[62]

Shell-trumpets, made from *Triton tritonis* and other large shells, enter largely into the religious ceremonies of the Samoans.

In his description of the religion of these people, Turner[63] relates that "in their temples they had generally something for the eye to rest upon with superstitious reveration. In one might be seen a conch shell, suspended from the roof in a basket made of cinnet network; and this the god was supposed to blow when he wished the people to rise to war."

The Samoans have a host of imaginary deities, and these gods are supposed to be incarnate in some visible object, the particular thing in which the god appears being an object of veneration.

Faamalu (shade), one of the village gods, was represented by a trumpet-shell, and at the annual worship of this god all the people met in the place of public gatherings with heaps of cooked food. Another local god was called Tapaai (Beckoning) and was a war god of a family on Tutuila. He was supposed to be present in a trumpet-shell. When the people were about to go to war the shell

[61] Lubbock, "Prehistoric Times," 1865, pp. 358 and 369. Captain Cook also mentions the "Triton's trumpet" as one of the sonorous instruments of the New Zealanders.

[62] G. A. Cooke, "System of Universal Geography," London, i., 1801, pp. 77 and 97.

[63] G. Turner, "Samoa, etc.," London, 1884, p. 19.

was blown by the priest, and all listened. If it blew rough and hollow it was a bad sign; but if clear and euphonic all were cheered, and went off joyfully under the good omen. In the island of Savaii a village god named Titi usi (Glittering leaf girdle) was worshipped at the new moon, and after prayer and feasting a man went about blowing a shell-trumpet as a sign that the ceremonies were over, and that the usual routine of village and family life might be resumed.[64] A further use of shell-trumpets noted by Turner in Samoa was to herald the approach of some important personage. A chief of importance must have one, or perhaps two, large shells in his canoe, to answer the purpose of trumpets, to blow now and then as the canoe passed along.[65]

In Manahiki, or Humphrey's Island, Turner states that when the constellation Pleiades was seen there was unusual joy expressed by singing, dancing, and blowing shell-trumpets.[66]

In the Society Is. large shells of *Triton tritonis*, L. are used as trumpets, and these are blown when processions walk to the temple, or warriors march to battle, at the inauguration of the king, during the worship at the temple, or when a tabu, or restriction is imposed in the name of the gods. Ellis[67] tells us that large shells were selected for this purpose, and these were sometimes above a foot in length, and seven or eight inches in diameter at the mouth. In order to facilitate the blowing of the trumpet, a perforation, about an inch in diameter, was made near the apex of the shell. Into this a bamboo cane, some three feet in length, was inserted, and secured to the shell with fine braid. The outside of the aperture

[64] Turner, *op. cit.*, pp. 27, 54, 60.
[65] *Ibid.* pp. 165-6.
[66] *Ibid.* p. 279.
[67] "Polynesian Researches," i., 1836, pp. 196-7.

was rendered air-tight by a resinous gum from the bread-fruit tree. These trumpets are also used by the herald, and on board the native fleets.

Captain Cook also speaks of the natives of Toobouai Island blowing large conch-shells in a long tone without any variation; but what it portended he could not ascertain.[68]

Hutchinson[69] gives a casual reference to the shell-trumpets of the Marquesas Islands, saying that they differ from that known as "Bosina" in Peru (see below).

In Micronesia, shell-trumpets are recorded as in use at Ponape (Ascension Is.), Caroline Islands, and in the Marshall Archipelago.[70] Of their use in the Pelew Islands, Captain Wilson tells us that in 1783, as a preliminary to an attack on a neighbouring enemy, the king, Abba Thulle, ordered the conch to be sounded as a signal for forming the line of battle. Captain King also refers to the blowing of the conch as a signal of defiance and warning in the Sandwich Islands.[71]

In the New World we have several instances of the use of shells as trumpets. A species of *Triton* was used formerly by the Indians of South America as a trumpet, and a specimen was dug up at Cañete, in Peru. The shell was called "Bosina," on account of the sound produced by blowing into it resembling the roar of a bull, and it was used to announce the approach of any great man into a town. It was ornamented with tassels of human hair, and a leather strap of exquisite workmanship.[72]

[68] G. A. Cooke, *op. cit.*, i., p. 65.

[69] *Journ. Anthrop. Inst.*, iv., 1874, p. 13.

[70] O. Finsch, "Ethnologische Erfahrungen und Belegstücke aus der Südsee," *Annal. des K. K. nathist. Hofmuseums*, Wien, 1888—93, *fide* Schmeltz, *op. cit.*

[71] G. A. Cooke, *op. cit.*, i., pp. 306 and 353.

[72] Lovell, *op. cit.*, p. 196, quoting Hutchinson's "Two Years in Peru," vol. i., p. 134.

An interesting survival of this practise in Central America is recorded by Theobert Maler in his "Researches in the Central Portion of the Usumatsintla Valley."[73] On p. 33 of his paper he relates how his arrival at the Indian settlements at Pethá was greeted by the blowing of conch-shell trumpets made from *Strombus gigas.*

According to Pinart,[74] the musical instruments of the present natives (Guaymis) of the Chiriquian region of Panama are limited chiefly to the bone-flute and the marine conch-shell. He describes one of their ceremonies, the balza, in which the conch-shell plays an important role. When a village has decided to give a balzaria and the date has been fixed upon, notice is given to other villages inviting the inhabitants to attend. Everyone is invited, men and women, young and old. According to the distance away, each family group sets out in time to arrive at the place of meeting two days before the commencement of the ceremonies. During the journey, the invited guests blow from time to time on large conch-shells in order to make known to all persons living near the line of route their passage and the purpose of their journey.

Pinart believes the Guaymis to be the descendants of the race that constructed the ancient huacals from which so many Chiriquian antiquities have come. This ancient race has left behind them numerous examples of wind-instruments of clay, modelled in the form of animals and birds. One of these figurines serving as a whistle represents a mythical form holding something resembling a fish or conch-shell a little distance from the mouth.[75]

[73] *Memoirs Peabody Museum*, ii., no. i., 1901.

[74] Alphonse Pinart, "Les Indiens de l'Etat de Panama," *Rev. d'ethnog.*, vi., 1887 pp. 33, 117, (quoted by Mac Curdy, "A Study of Chiriquian Antiquities," *Memoirs Conn. Acad. Arts and Sciences*, iii., 1911, pp. 169-170).

[75] Mac Curdy, *op. cit.*, p. 185, fig. 315.

An analogous idea is expressed in a beautiful Chiriquian gold casting of two human figures with elbows touching and holding to their mouths something that resembles a conch-shell or a fish.[76]

Robert Brown relates that the descendants of the Incas, in Peru, under the rule of Francesco de Toledo, in 1568, held periodical festivals in memory of their beloved sovereigns, when plays were enacted and mournful music produced from the national instruments, drums, trumpets, clarions, and *putatus*, or sea shells.[77]

According to von Martens,[78] the Jesuit priest Arriaga, at the beginning of the 17th century, also describes the use of shell-trumpets in Peru, and in the Bolivar collection of the Berlin Ethnographical Museum there is a pre-Columbian trumpet made of *Strombus galeatus.*

The Portuguese writer, Suarez de Sousa, in 1589, and Marcgrave, about 1640, report on the use of trumpets in Brazil, made probably of *Strombus goliath.*[79]

In a paper on the ruins in Casa Grande, in Southern Arizona,[80] J. W. Fewkes states: "Among the more numerous marine shells which were found in Compound B of the Casa Grande group of ruins are many large conchs, the points of the spires of nearly all of which were ground off and perforated as if for trumpets. Judging from known ceremonies of the Hopi, it is highly probable that these trumpets were used in dramatic celebrations in which effigies of the great serpent were introduced, the priest using the instruments to imitate the supposed roar of this animal. More than a dozen complete specimens, and many fragments of conch shells that may have been parts

[76] *Ibid.* pp. 185. 209, and pl. xlix., fig. A.
[77] "Races of Mankind," i., N.D., p. 316.
[78] Von Martens, *op. cit.*, p. 485.
[79] *Ibid.* p. 485.
[80] *28th Ann. Rept. Bureau of Amer. Ethnology*, 1912, pp. 144—5.

of trumpets, were found in the course of the excavations at Casa Grande, the greater number being obtained on the west side of Compound B. All these shells came originally from the Pacific coast."

G. H. Pepper, in his paper on "The Exploration of a burial-room in Pueblo Bonito, New Mexico,"[81] also records the discovery of a shell trumpet, made from *Strombus galeatus*. It had evidently been cracked in use and showed signs of repair. Associated with it was a human skeleton; also *Haliotis* shells, and 26 perfect shell bracelets and 15 fragments. The bracelets, he adds, averaged 8·5 c/m. in diameter, and are probably made from *Pectunculus* shells. In other parts of the room were further shell bracelets, pendants, and beads, of *Olivella* shells; also ornaments of turquoise and shell mosaic.[82]

Carl Lumholtz, in an interesting paper on "Symbolism of the Huichol Indians,"[83] gives us details of the use of a species of *Murex* as a trumpet at ceremonies and feasts. After describing various other objects used at the feast of *tamales de maiz crudo*, he states (p. 185): "At the same feast, but only on the eastern side of the river, seashells are employed as a kind of musical instrument. When the heap of *tamales* is dedicated to the gods by the shamans, some of the people are appointed to blow into such shells five times in the daytime and five times at night. This is done as a signal to all the gods. After the feast the shells are carried to Mesa del Nayarit, where they remain through the wet season, to be afterwards brought back again for the next feast of the same kind. They are kept in Mesa del Nayarit in a god-house. According to tradition, the Chichimecas brought them first from that part of the coast where San Blas is to-day."

[81] Putnam Anniversary Volume 1909, p. 226.

[82] This mosaic recalls the beautiful *Haliotis* inlay of Japanese artists.

[83] *Mem. Amer. Mus. Nat. Hist.*, iii.; *Anthropology*, ii., 1900.

Lumholtz was unable to procure any shell that had actually been used at the feast, but he found one in the god-house of the Sun (Tayau') in Têaka'ta, which, according to his informants, was smaller than those used. The species is *Murex* (*Phyllonotus*) *radix* Gmelin, from the South Pacific Ocean, west coast of America. In Huichol it is called Ku'ra. Much difficulty was experienced in buying the specimen; the man who had deposited it, and who was one of Lumholtz' party, at first absolutely refused to part with it. Although left some years ago, it still remained to him a valuable prayer for life. Through the acquirement of this specimen, which was the only one seen in the god-houses, Lumholtz learned of the interesting custom of blowing into shells just related. The natural markings on this shell symbolize to the Huichols grains of corn and water.

Probably the most remarkable occurrence of the use of shell-trumpets in the New World is afforded by Mexico. Von Martens[84] refers to the finding, by Seler, of prehistoric trumpets made from *Fasciolaria gigas*[85] and *Turbinella scolymus* from the Caribbean Sea, and *Fasciolaria princeps* from the Pacific Ocean, in several parts of Mexico.

From ancient Mexican manuscripts we learn that conch-shell trumpets entered largely into the religious ceremonial of the Aztecs.

In Seler's description of Codex Vaticanus, No. 3,773, reference is made to the blowing of shell-horns in the temples at midnight, as a signal for the priests to arise and mortify themselves, to sing, and then go in procession to the bath.[86]

[84] Von Martens, *op. cit.*, p. 485.

[85] Probably *F. gigantea* is meant here.

[86] Edward Seler, "Codex Vaticanus, No. 3,773 (Codex Vaticanus B), an old Mexican pictorial manuscript in the Vatican Library," Berlin and London, 1902-3, English translation by A. H. Keane.

In the same work and elsewhere *moçauni*, the Fasting Man, Ruler of the Nineteenth Day-count *quiauitl*, "Rain," is figured blowing a conch-shell and associated with *Tonatiuh*, the Sun God.[87] A reproduction is also given of an illustration from the pictorial manuscript in the Florentine Biblioteca Nazionale showing *Xochipilli*, the God of Flowers and Food Supplies, being carried in procession preceded by a priest blowing a conch-shell trumpet.[88]

Further illustrations of the use of the shell-trumpet are seen in Codex Borgia 14, where *Tepeyollotli*, the Heart of the Mountains, God of the Caves, is figured blowing the shell-horn, and in Codex Vaticanus, No. 3,773, sheet 22, where the same god wears the shell-horn as a breast ornament and a second horn lies before him at the threshold of the temple.[89]

The remarkable identity in the Hindu and Mexican use of shell-trumpets in temple worship and harvest rites, and the association of the shell with the God of the Moon, has recently been pointed out in a previous article.[90]

Since this paper has been printed I have discovered that on the appearance of De Soto's soldiers in 1539 the Indians of Florida and the Chickasaw country were roused to action by the blowing of horns and conch-shells, and the beating of drums.[91]

[87] Seler, *op. cit.*, p. 185, fig. 393, and sheets 28 and 94. The shell is probably *Fasciolaria gigantea*.

[88] Seler, *op. cit.*, p. 162, fig. 363. The shell looks like a reversed *Cassis cornuta*. This species is common to the West Indies, Pacific Islands, etc., and is used as a trumpet in Papua and other Pacific Islands.

[89] Seler, *op. cit.*, p. 103, figs. 295, and p. 105, sheet 22. Here the shell is like that of the Fasting-man, i.e., *Fasciolaria gigantea*.

[90] Jackson, "The Aztec Moon-cult and its relation to the Chank-cult of India." *Manch. Memoirs* (*Lit. and Phil. Soc.*), vol. 60, pt. ii., 1916.

[91] Grace King, "De Soto and His Men in the Land of Florida," New York and London, 1914, pp. 39 and 187.

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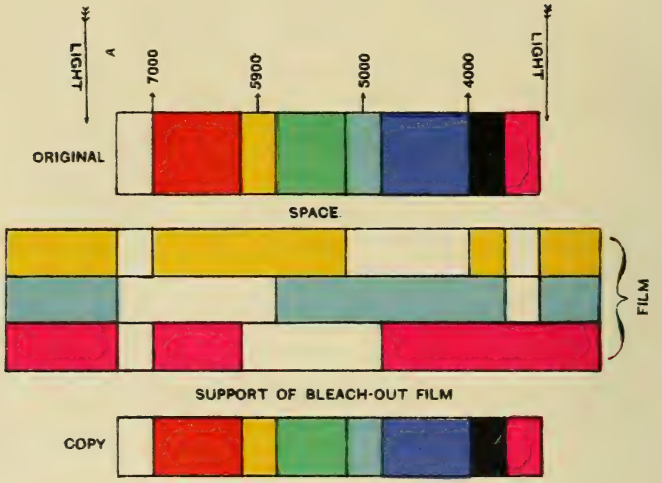

Fig. a. illustrating the result of printing upon a bleach-out film containing three dyes.

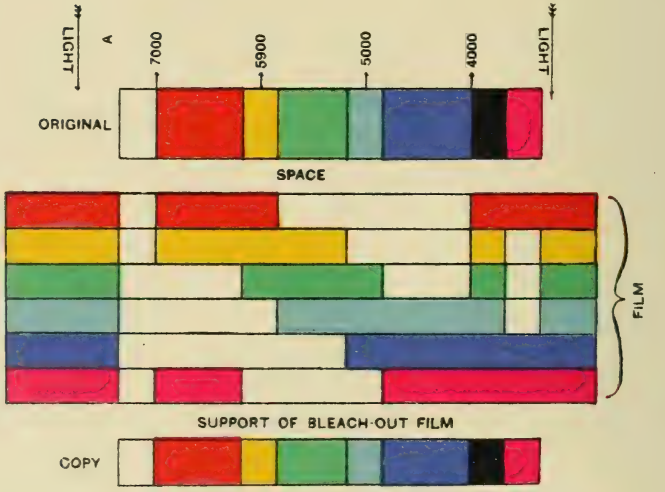

Fig. b. showing the result of printing upon a bleach-out film containing six dyes.

Manchester Memoirs, Vol. lx. (1916), *No.* 9.

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IX. A résumé of work on the bleach-out process of colour photography.

By John H. Smith, Ph.D., F.I.C., A.R.C.Sc.I.

(Communicated by Mr. R. L. Taylor, F.C.S., F.I.C.)

(Read February 22nd, 1916. Received for publication March 23rd, 1916.)

The bleach-out process of colour photography is based primarily upon the instability of certain natural and artificial colouring matters to light. The fading action of light upon many coloured bodies was observed long before artificial dyes were discovered.

Grothuss (1) in 1819 seems to have been the first to have attempted to formulate the nature of the action of coloured light upon bodies. He writes: "Coloured light seeks to destroy, in bodies upon which it acts, those colours which are opposed to its own while it endeavours to retain its own or another analogous colour." If instead of "opposed" we substitute *complementary* colours, we have the first reference to the fundamental principle underlying the bleach-out process of colour photography.

Sir John Herschel (2) writing on the same subject in 1842 says: "The rays effective in destroying a given tint are in a great many cases those whose union produce a colour complementary to the tint destroyed, or at least belonging to that class of colours to which such complementary tints may be referred. For example, yellows tending towards orange are destroyed with more energy by the blue rays, blues by the red, purples and pinks by yellow and green rays."

July 5th, 1916.

Becquerel (3) confirmed in 1848 in a general way Herschel's conclusions.

Draper's law, which affirms that chemical action by means of light can only result from the light rays absorbed by a body, and not by those it transmits or reflects, must lead one also to the same conclusions. This law, according to Luther, should be attributed to Grothuss, as the latter affirms (4) that "this absorption in the substance of the body must be the cause, at any rate in many cases, of a considerable chemical action."

Liesegang (5) in 1889 was the first to propose a process of colour photography based upon the bleaching out of dyes in complementary coloured lights. He writes: "The theoretically most correct method of colour photography is that which is based upon the following principle. It is already known that a dye is decomposed only by that light which it absorbs or by its complementary colour. Certain aniline dyes bleach very rapidly in light. If we mix pigments of the three primary colours, red, green and blue, we obtain black. If we produce this black upon paper by means of very sensitive dyes, and place a red coloured picture upon it; light green, *i.e.*, blue and yellow, will bleach out so that only red remains. In the same way blue only remains under blue, green under green, etc. Naturally the dyes must correspond fairly well with the colours of the spectrum and be of the same sensitiveness. The production of such a print would occupy too long to be practically useful. It is possible, however, to obtain the same result with more sensitive materials. The aniline coloured print must be protected from the further action of light by varnishing, etc."

According to this proposition of Liesegang, each colour in the original will be reproduced in the bleach-

out film, and we shall obtain a reproduction of the coloured original in its own colours *direct* and not from an intermediate negative as in ordinary photography.

The accompanying coloured plate (*Fig. a*) shows the action of light upon a bleach-out film containing three dyes, not of the primary colours as Liesegang suggests, but of the secondary colours yellow, blue-green and pink, as these are necessary on account of the greater luminosity of the colour mixtures; the bleach-out process being based upon the subtractive process of colour mixtures like three-colour printing. The three dyes in the film are supposed to be applied in three separate layers in order to simplify the demonstration of the process. The same principle holds good in the case of dyes mixed up in one layer, the process more generally employed. The coloured original to be copied may be a natural spectrum, coloured glasses, a coloured window transparency, natural leaves or flowers pressed flat, a photographic three-colour transparency or a Lumière Autochrome photograph. In the last-named subject, the most difficult of all to print, the starch granules employed in the manufacture of the plate are coloured in the three primary colours orange-red, green and blue-violet, allowing only the light of the visible spectrum to pass of approximately 7,000—5,900, 5,900—5,000, and 5,000—4,000 wave length respectively as shewn in *Fig. a*. The position of the secondary colours yellow and blue-green have been indicated by narrower bands, while the pink not being a spectrum colour has been shown outside. Narrow bands of black and of transparency to the whole visible spectrum (white) have also been added to show the effect of these also on the bleach-out film.

In the case of the transparent band all three dyes are bleached out and we obtain a colourless band in the copy.

The light passing through the red of the original bleaches the blue-green but not the yellow or the pink, and these colours combined reproduce the orange-red of the original in the copy ; yellow or red plus green light bleaches both blue-green and pink leaving yellow, green light bleaches pink leaving blue-green and yellow producing green again in the copy ; blue-green, allowing green and blue light to pass, bleaches the yellow and pink dyes leaving the blue-green in the copy ; blue-violet bleaches the yellow dye leaving the blue-green and pink dyes producing the original blue-violet in the copy while the pink allowing blue-violet and orange-red to pass bleaches out the yellow and blue-green dyes leaving the pink dye intact. As the black band allows no light to pass, all three dyes in the film remain unbleached leaving the black film unaffected. Other coloured mixtures, and varied coloured intensities, or mixtures with grey, etc., in the original are reproduced in the copy by partial or more intense bleaching, etc., of the corresponding complementary dyes in the film.

Vallot (6) in 1895, and Neuhauss (7) and Worel (8) in 1902 were the first practical workers in this interesting field, and some of the results obtained were fairly satisfactory for the conditions obtaining at that time. Neuhauss had difficulties in getting results on paper, so he coated his emulsions on glass and opal. Worel did not emulsify his dyes, but used simply dye solutions which he transferred to paper. He discovered the use of anethol as a sensitiser for the dyes. Neuhauss used peroxide of hydrogen as a sensitiser, and was even able to obtain direct photographs in colours in the camera with very long exposures. The dyes he employed were erythrosine, auramine and methylene-blue. Worel employed victoria-blue and curcumine.

The results obtained at that time were crude; the colours were not rendered harmoniously and the exposures were very long. Still some very fair reproductions of brilliantly coloured window transparencies were obtained.

These workers were soon followed by Szczepanik and by myself. Szczepanik (**9**) patented a process by which the separate dyes were embedded in different layers with a view to preventing the dyes from reacting injuriously on each other. He used practically the same materials as Neuhauss and Worel, but his results were not much better in spite of his much more complicated method of working. His paper was, however, the first obtained by coating a paper support directly with dyed emulsions.

In 1904, after prolonged research, I placed a bleach-out paper on the market, the first of its kind. I had naturally profited by the work of my predecessors, but there were several noteworthy improvements in this first commercial paper, introduced by my then co-worker Dr. Merckens and myself. The dyes employed were to some extent new and prepared by ourselves, and we were able to bring all the dyes into *one emulsion layer upon paper.*

Szczepanik (**10**) employed alternate layers of collodion and gelatine for coating his dyes upon paper, while we were able to obtain our dyes in a single layer of collodion. To prevent the emulsion from penetrating into the body of the paper we had a thin insulating film of gelatine coated on the paper first. Anethol was used as a sensitiser.

We studied the action of various dyes upon gelatine and collodion, and found (**11**) that the basic dyes had generally strong affinity for the collodion, while the acid dyes showed more affinity for gelatine. The affinity of the dyes is sometimes so great that they will not only leave a medium of lesser affinity for one of greater affinity

which adjoins it, but they are capable of passing through a layer of lesser affinity in order to reach a medium of greater affinity, and that whether the layer of lesser affinity contained already a dye of its own affinity or not.

Absolutely neutral media probably do not exist, and it was not found practicable to separate dyes in media of low affinity from media of high affinity by means of insulating layers.

As former workers had used both acid and basic dyes it was quite natural that they had met with the difficulty of getting them to remain in one and the same vehicle, and that Szczepanik had sought to overcome the difficulty by separating the dyes into different layers. We had been successful in finding a series of basic dyes which had no tendency to migrate from their emulsion, collodion, as long as this was separated from the body of the paper support (for which the basic dyes have a similar, although mostly inferior, affinity to collodion) by a layer of gelatine.

This first paper which I manufactured under the name of "Uto" paper was used chiefly for the reproduction of coloured window transparencies, "Glacier" prints, natural leaves and flowers, three-colour transparencies and the like.

In the summer of 1907 the Autochrome plate was put on the market by Lumière Bros. in Lyons, and it was hoped that the "Uto" paper would be found adapted for the reproduction of these plates. Unfortunately this was found not to be the case. Many difficulties had still to be overcome and improvements had to be made before this result could be accomplished, and I was engaged upon this investigation during the following four years.

It was found necessary to obtain :—

(*a*) The annihilation of the reproduction of the Autochrome colour screen.

(*b*) More regular bleaching of the individual dyes.

(*c*) Quicker printing.

(*d*) Reduction of the heat developed in the Autochrome plate by the long exposures.

(*e*) Greater saturation of the colours.

(*f*) Better fixation of the dyes remaining after printing.

The reproduction of the colour screen image could be got rid of by the introduction of a thin celluloid film between the Autochrome plate and the sensitive paper. This precaution was not even necessary in printing in diffused light, as there was sufficient diffusion in the sensitive film in this case, but the exposure was of course greatly prolonged.

The equalising of the bleaching action of the individual dyes gave most trouble. Although we have to-day a few thousand different aniline dyes, they are for the most part too stable to light to be employed even with the aid of a strong sensitiser for the bleach-out process. Amongst those which might be sufficiently fugitive, many are excluded on account of their bleaching, not to a white, but to another shade, giving a dirty appearance to the print. Others are debarred from employment on account of the colour of the dye being recuperated when the print is left in the dark; others could not be used for want of suitable companions of the correct shade of colour or speed of bleaching; while others again bleach in such an erratic way as to preclude their employment.

I have examined many hundreds of dyes with regard to their bleaching qualities, and I think I am safe in asserting that no three are to be found which fulfil in a thoroughly satisfactory manner all the varying demands which are placed upon them, viz.:—

Sufficient and equal natural sensitiveness to light.
Amenability to the influence of known sensitisers.
Bleaching in regular intervals from the full colour always through the same shade of colour to white.
No recuperation of the colour after printing.
The possibility of fixing the remaining dyes thoroughly after printing.

The first and last of these conditions are hardly compatible with each other: a compromise has to be made. I know of some fugitive dyes which can be sensitised to such an extent as to give prints from Autochromes in 5—10 minutes in strong sunlight, but it seems so hopeless to attempt to find a satisfactory method of fixing these dyes as to preclude their use altogether. I prefer to employ dyes of fair natural stability, amenable to being strongly sensitised, and to eliminate the sensitisers well after printing.

In order to obtain sufficiently regular bleaching of a dye there are some conditions which must be fulfilled which have not been taken fully into account by writers on this subject. On referring again to the coloured plate it will be seen that the theory of the process requires that a dye should be stable in the light of about half of the visible spectrum and bleach-out in the other half of complementary colour. Now this is far from being an ordinary property of dyes. They usually absorb light in narrow bands and this tends to produce degraded colours in bleaching. There is a spreading out of the absorption bands on prolonged exposure so that we get an approximation to the desired conditions. This spreading out of the absorption bands on increased exposure occurs, however, in many cases only on one side of the spectrum, a solid wall being built up on the other side beyond which

no absorption takes place. *Fig.* 1 shows an example of this form of absorption. Dyes which have their chief absorption at that point of the spectrum where their exact complementary colour lies, and whose absorption on increased exposure spreads out equally on both sides of this centre give naturally the best results.

Some dyes again have two or more absorption bands as shown in *Fig.* 2 This is not of much account so long as they are not too far apart, the centre of the absorption is at the complementary point, and the bleaching occurs equally in all the bands. As dyes do not always bleach in all their absorption bands this leads to many anomalies. Many blue dyes are peculiar in this respect. I was astonished one day to find a blue dye which bleached much more readily under its own colour than under the complementary colour. This I found was due to the action of the violet and ultraviolet rays where the dye bleached rapidly, while there was little bleaching in the absorption bands in the orange. The dye bleached practically as a yellow dye, and not according to Liesegang's bleach-out proposition. Under a yellow colour the violet and part of the ultra-violet rays were cut off, so the dye bleached slower than under a blue colour which allowed these rays to pass. *Fig.* 3 shows an example of a dye of this description.

Many dyes—and again, in particular, blue ones—had other peculiarities. Some would recuperate their colour partially in the dark, while others would bleach out but have their colour restored on dipping in a weak acid solution. These dyes were of course valueless.

As I was not successful in finding three dyes which fulfilled the necessary conditions sufficiently, I was led to introduce a larger number of dyes into the emulsion, with a view to the one equalizing the action of the other. In

this way I have employed so many as eight or ten, and even more dyes in an emulsion with advantage. I am, in fact, of opinion that a series of six dyes, one set of the three primaries and another set of the three secondary colours, would be preferable to a series of three colours only, if they could be found with the necessary properties. *Fig. b*, on the coloured plate, shows the bleaching action on a film containing six dyes in place of three when exposed under a coloured original to print.

I am quite aware that there would be some degradation of colour by the use of the primaries where their mixtures are concerned, but if they were selected to transmit two-thirds of the visible spectrum as the complementaries have to do, and not only one-third as is required in the screen colours of the Autochrome plate or in the screens for three colour photography, the degradation of colour would not be so appreciable, and the defect would be more than compensated by the purity of the colours and their immunity from bleaching at seven points of the spectrum instead of only at four points (the pink being supposed to be represented by the overlapping of the extreme ends of the visible spectrum).

I cannot claim that in practice the increase in the number of dyes I employed was even an approximation to these theoretical conditions, as I had to consider in the first place the correction of the defects of my chief dyes by supplementary ones.

In my endeavours to increase the sensitiveness of the paper I discovered in thiosinamine a new sensitiser which possessed many valuable properties. It sensitised for many dyes twenty times more energetically than anethol, the most active sensitiser known up to that time. It possessed the further advantages of being easily soluble in water and in alcohol, thereby being easily removable

from the film after its work had been done, and in its being perfectly odorless.

In order to obtain sufficient saturation of the colours in the print it was necessary to incorporate much more dye into the emulsion in the case of printing from Autochrome plates than was necessary for printing from window transparencies and the like, because there was considerable loss of colour in breaking through the grey tone of the Autochrome screen to produce good whites. This led again to a slowing down of the emulsion, and it was hardly feasible to obtain a quicker printing of an Autochrome of medium density than in about two hours in sunlight. The Autochromes would not stand such a long exposure to the sun, they became over-heated and the colours disappeared, a positive in black and white ultimately resulting. This effect was not due to any bleaching-out of the colours, but to a melting of the varnish containing the coloured starch granules, thereby mixing up the colours in the film and producing an even grey colour. This difficulty was obviated by withdrawing the printing frame from the sun at intervals, and allowing the Autochrome to cool, preferably by applying a wet sponge to the glass or using some such other device. By taking adequate precautions it has been found possible to print over a hundred copies from one Autochrome plate.

I am sorry to state that the fixing of the dyes has only succeeded very imperfectly. The prints may be kept any length of time in albums, but they are not permanent enough to hang up in rooms for any length of time without suffering.

The sensitisers are washed out of the film, and an attempt has been made to mordant the dyes, but the results leave much to be desired.

In printing from Autochromes it is necessary, in order

to keep the balance of the colours, to employ colour screens in front of the printing frame. These may require to be changed according to the nature of the light which is employed. In sunlight the prints print redder in tone and in diffused light bluer. The blue tone is obviated by a light orange filter, and the red tone by a light green filter. The yellow in the screens helps to negative any bleaching action by the ultra-violet rays. In printing by the electric arc, which is richer in orange rays, a deeper coloured green filter must be employed.

In my experiments with the dyes, I found several of the acid ones which could be sensitised very satisfactorily, and as I was anxious to use gelatine as a vehicle instead of collodion, on account of its many advantages, I ultimately went over to gelatine emulsions altogether. I was not, however, altogether dependent upon the sole use of acid dyes, because in the meantime I had found that I could obviate the wandering of many basic dyes out of gelatine to some extent by the addition of a soluble oil such as Turkey-red oil, for which these dyes have considerable affinity.

In order to hasten the process of printing I devised a special form of printing frame (**12**) surrounded by four mirrors which reflected the rays of the sun or arc down upon the plate. To prevent the Autochrome becoming overheated a constant stream of water was flowed automatically over the surface of the plate. By this means the time of printing was reduced to about one-third.

My new bleach-out paper was placed on the market in Paris, in 1911, under the name of "Utocolor," and there was always a certain demand for it until the war broke out, when naturally the sales suddenly stopped.

Very little has been published in recent years on the bleach-out process. Professor Limmer (**13**) has published

a history of the process and done some interesting work himself, both with regard to the bleaching and the sensitising of the dyes. Dr. Gebhardt has also published some useful work upon the nature of the action of light upon dyes, and the treatment of the dyes to render them more stable. Dr. Stobbe (14) also published some interesting work with regard to the action of light upon dyes a few years ago.

In 1913 Dr. Alex. Just (15) discovered a new sensitiser, di-ethyl-allyl-thio-urea, which for a certain group of dyes sensitises about three times more energetically than thiosinamine (allyl-thio-urea). Unfortunately it has not been found applicable for sensitising all the dyes required in a bleach-out film. It is indeed hardly possible to find a sensitiser which acts upon all the dyes employed. Even in the case of thiosinamine the employment of other sensitisers is necessary to assist in obtaining regular bleaching action. In 1908 I published the results of an extended investigation into the sensitising effects of a very large number of bodies (16).

Attempts have been made to develop lightly printed bleach-out prints by Kümmel, Gebhardt, Limmer and myself (17), and although certain results have been obtained nothing of a practical nature has resulted from the experiments.

It is a pity that there are so few workers in this interesting branch of science. Two of my most active co-workers, Dr. Neuhauss and Dr. Gebhardt, have fallen a prey to the war, and the few remaining ones belong, unfortunately, all to enemy countries.

I have brought a collection of thirty prints upon "Utocolor" paper, mostly from Autochromes, to show the nature of the results obtained.

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10. In the *Photographische Industrie*, 1908, p. 1069, I have criticised Szczepanik's method fully.

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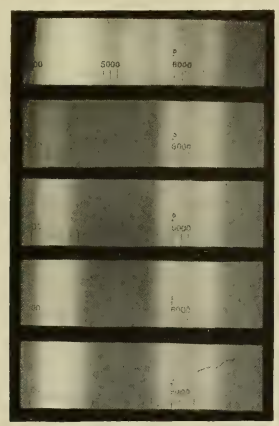


Fig. 1 showing widening absorption towards one side of spectrum on increased exposure.

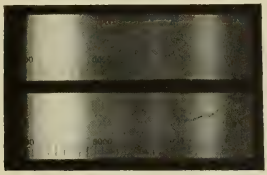


Fig. 2 showing absorption of dye in three distinct bands.

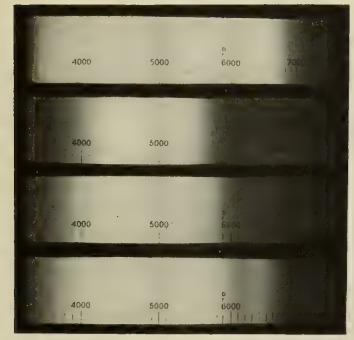


Fig. 3 showing absorption of blue-green dye bleaching chiefly in its less intense (violet) absorption band.

Manchester Memoirs, Vol. lx. (1916), *No.* **10**.

X. Quantitative Absorption Spectra. Part II. A New Ultraviolet Photometer.

By Frederick Russell Lankshear,
B.A. (N.Z.), M.Sc. (Vict.).

(*Read December 15th, 1914. Received for publication March 9th, 1915.*)

In a previous communication (October, 1914) certain quantitative methods of examining absorption spectra were described and it was mentioned that an instrument was being made with a view to overcoming difficulties due to the intermittent nature of the light received upon the photographic plate. The present communication is a brief description of the instrument made by Messrs. Bellingham and Stanley.

Optical System. *Fig.* 1 shows diagrammatically the optical system used.

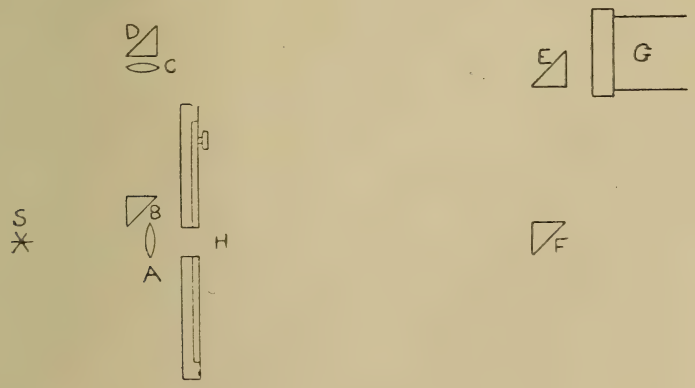


Fig. 1.

All the optical work is of quartz. Light from the spark source *S* falls on the condenser *A*. This beam can

for convenience be called the standard beam. It passes through the centre of the adjustable sector disc *H* and falls on the prism *F*. It is reflected by *F* on to the prism *E* from which it emerges horizontally, coming to a focus on the spectrograph slit *G*. The prism *B* transmits another beam, of equal intensity, upwards through the the condenser *C*. Then the prism *D* reflects the beam horizontally through the Baly tube or other containing vessel for the solution under examination. The beam comes to a focus on the slit immediately above and also touching the standard beam.

The Frame. The frame upon which the optical parts are set consist of two aluminium uprights held together by three stout brass rods. That nearest the source of light carries a brass bracket on which are placed prisms *B* and *D* along with the condenser *C*. This upright or end piece carries the sector bush in which is mounted the standard beam condenser. The other end piece carries a brass bracket for the two prisms *E* and *F*.

The Sector. The chief feature of the apparatus is the sector. Instead of slots out near the periphery as in all other sector photometers, there is a single semicircular hole out at the centre with its diameter passing through the centre of the wheel (*Fig.* 2). A disc having a corre-

Fig. 2.

sponding hole in it can be rotated on the face of the sector wheel, thus altering the aperture of the sector. The latter is graduated logarithmically because the

measurement is of $\log I_1/I$. In view of the possibility of slight defects in the condenser *A*, the sector has been constructed to rotate if necessary. This can be done either by hand or by clockwork.

Adjustment. A white disc bearing a small black cross at its centre is set up in the position of the spark *S* and illuminated by a lamp. The preliminary adjustment is done by means of screws on the bracket carrying prisms *E* and *F*. When this is properly done, the eye, placed at *E*, can see a circle of light bisected by a larger semicircle. The eye is then moved back ten inches and the other bracket screwed up until the upper portion of the cross transmitted by the upper path is seen to form a complete image with the lower portion of the cross transmitted by the lower, or standard beam (*Fig.* 3). The

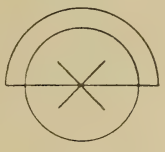


Fig. 3.

instrument is now in complete adjustment and has now to be placed with the top prism *E* nearly touching the middle of the slit and with the upper path in the optical axis of the spectrograph. The spark *S* is placed in the position of the illuminated disc.

Advantages. In all other methods of ultraviolet photometry the intermittent nature of the light makes a correction necessary. Schwartzschild's formula is used, *i.e.*

$$I/I_1 = t_1/t^n.$$

In the case of Wratten panchromatic plates $n = 0{\cdot}9$. In the Hilger instrument this difficulty is to a certain extent obviated by calibrating the plates in terms of a piece of

glass of known extinction. This is somewhat tedious and does not quite do away with the possibility of error. The central sector acts by cutting down the beam, which nevertheless falls continuously on to the photographic plate. Further, in the Hilger instrument, the greatest length of liquid which can be used is 5 cms. With the new apparatus a Baly tube can be used, and with one solution the extinction coefficient over a wide range of the spectrum can be determined. Finally, because the image is focussed on the slit instead of on the object glass an increased amount of light is obtained in the spectrograph.

Manchester Memoirs, Vol. lx. (1916), *No.* **11**.

XI. The Theory of Overvoltage.

By Edgar Newbery, D.Sc.

(Communicated by Professor Arthur Lapworth, D.Sc., F.R.S.).

(Received and read May 9th, 1916.)

When a metal such as copper is placed in a solution of one of its salts, it immediately throws out ions of itself into the solution, each carrying a positive charge and leaving the metal itself with a negative charge. At the same time ions from the solution carrying a positive charge will deposit on the metal, and in a very short interval of time a state of balance will be set up when the number of ions leaving the metal will be equal to the number arriving, *i.e.*, the solution pressure of the metal will be equal to the osmotic pressure of the ions. When this state is reached there will be a definite difference of potential between the metal and the solution (single potential difference) which will depend on the nature of the metal and the concentration of the solution.

If a gas such as hydrogen or oxygen be bubbled round a thin sheet of metal, preferably of platinum or palladium, the metal will act as if it were composed of a sheet of conducting gas, its own properties being lost for the time, and the gases on the metal will give out and receive ions in the same way as a metal. If we take two such electrodes, one surrounded with hydrogen and the other with oxygen in an acid or alkaline electrolyte, we shall

have an electrolytic cell with an E.M.F. of about 1·12 volt.

This cell is reversible, that is to say, if we allow it to give a current, hydrogen and oxygen will unite to form water, while if we pass a current through the cell in the opposite direction, the same gases will be generated from the water present.

We should expect therefore that the same E.M.F., 1·12 volt, when applied to the above cell, would be just sufficient to decompose an acid or alkaline solution with formation of oxygen and hydrogen. In 1899, Caspari discovered that this was not the case, but that the E.M.F. necessary to liberate these gases was always greater than 1·12 volt, and further that the excess E.M.F. above the theoretical value was different when different electrodes were used, and was not the same for anode and cathode.

This excess E.M.F. he termed the 'Overvoltage' of the electrolytic cell.

In any electrolytic cell, therefore, when a current is passed through, a back E.M.F. is set up at each electrode opposing the applied E.M.F., and this back E.M.F. is in each case greater than that which would be obtained if the electrode were merely surrounded by the substance which is being liberated at that electrode.

We may therefore call this *excess back E.M.F.* at each electrode the Cathodic and the Anodic Overvoltage respectively.

Similar phenomena occur at the electrodes during deposition or dissolution of a metal, a back E.M.F. being set up at each electrode even when the same metal is being deposited at one electrode that is dissolved at the other. We may speak of such overvoltages as 'metal overvoltages,' while the term 'anodic or cathodic overvoltage of an electrode' will imply the overvoltage when

a gas is being liberated. Throughout this paper, cathodic overvoltage with liberation of hydrogen is generally implied, unless the contrary is stated.

If we attempt to reduce a substance electrolytically (in acid solution for example), then on applying a given E.M.F. to the cell, one of two things must occur at the cathode, (*a*) either the discharged hydrogen ions will react with the reducible substance present, or (*b*) they will combine with each other and escape in the form of gas bubbles.

Overvoltage hinders the formation of gas bubbles and thus encourages the former action to take place to the exclusion of the latter.

It might appear therefore that in order to reduce any substance electrolytically, we have only to choose a cathode of the right overvoltage, and given other suitable conditions (temperature, circulation of electrolyte, etc.). we should be able to obtain complete reduction before any hydrogen is liberated.

In practice the problem is by no means so simple.

Many electrolytic reductions may take place along two or more different paths leading to different end products, and in some cases the substance of which the electrode is composed may exert a specific influence in determining the proportions of the original substance which are reduced along the specified paths.

In such cases, overvoltage may be only of secondary importance.

The following example will illustrate this :

Sodium Nitrate in acid solution is reduced by a metallic cathode with formation of hydroxylamine and ammonia. Tafel studied this reaction with different electrodes and obtained the following results ; current density 0·24 amp. per sq. cm.—

Cathode.	O.V.	% Hydroxylamine.	% Ammonia.
Lead (rough) ...	0·60	26·8	57·6
,, amalgamated	0·85	69·7	19·9
Copper (smooth)...	0·35	11·5	76·8
,, spongy ..	0·10	1·5	93·8
Tin (smooth) ...	0·63	45·8	38·3

The overvoltages (approximate) at the given current density are given in the second column. From these it appears that the metal with the highest overvoltage gives the best yield of the less reduced product hydroxylamine. This is evidently due to the fact that hydroxylamine and ammonia are not primary products of reduction of nitrates, but are obtained by independent paths since hydroxylamine is not reduced to ammonia by a copper electrode under the conditions of the experiment.

Nevertheless, in the great majority of cases, overvoltage is the main controlling factor in electrolytic oxidations and reductions, and hence a knowledge of the overvoltage of the electrode in use under the given conditions, is of the greatest service in carrying out such processes.

Specially is this the case in the electrolytic treatment of organic substances for the preparation of dye stuffs, medicines, etc., where a slight change in the conditions of the experiment, by changing the overvoltage, may completely change the nature of the product obtained.

Further than this, in order to understand the problem thoroughly, it is necessary to obtain some idea of the nature of overvoltage, its causes and controlling factors.

An immense amount of work has been done by a great number of experimenters in attempts to measure and explain the causes of overvoltage, and it is proposed here to give a very condensed account of—

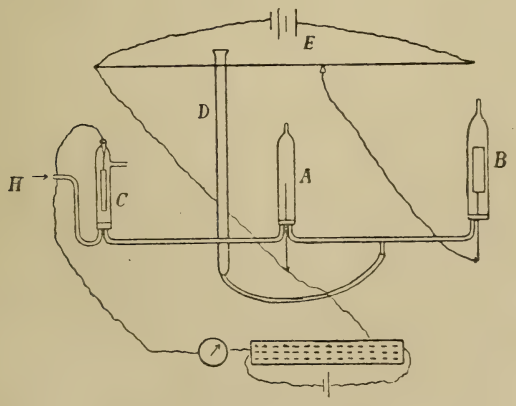
1. Methods of measuring overvoltage.
2. The most important phenomena connected with, and controlling factors of overvoltage.
3. The chief theories put forward to account for overvoltage.
4. Suggestions for a more comprehensive theory of overvoltage to account for all the observed phenomena as far as at present known.

1. Methods for Measuring Overvoltage.

a. By direct measurement of the potential difference between each electrode and a standard electrode while the current is flowing.

This is the method originally suggested by Caspari, and used by many others.

A diagram of Caspari's apparatus is given below.



Text-fig. 1.

In this diagram (*Text-fig.* 1), *A* represents the experimental electrode, *C* the standard hydrogen electrode. A gradually increasing voltage was applied to the electrodes *A* and *B* from the battery *E* until the first gas bubbles were observed on *A*, and then the potential difference between the electrodes *A* and *C* was measured by means of the potentiometer *F*. The electrolyte, normal sulphuric acid, was contained in the reservoir *D* by means of which the height could be adjusted.

This method gives reliable values for the overvoltage when an indefinitely small current is flowing, but unfortunately is not applicable to practical cases where appreciable current densities are employed.

Some investigators have attempted to use it in such cases and have drawn conclusions from their results which are not justified by facts.

Imagine the case when a fairly strong current is passing between *A* and *B*. Measure the difference of potential first between *A* and *C*, and then between *B* and *C*. These added together will of course give us the value of the applied E.M.F. Each of the above measurements will therefore give us little or no information about the overvoltage of either electrode, but merely shows the way in which the E.M.F. of the battery is distributed between the two electrodes and this depends on the relative size of the electrodes, the resistance of the film of gas on each electrode, the resistance of the solution and even of the battery and leads. The futility of such measurements may be realised when it is seen that changing the size or material of one electrode alters the apparent overvoltage of the other.

In Caspari's work, however, the whole of the applied E.M.F. was used up in overcoming the back E.M.F. of the two electrodes, and only an indefinitely small extra

E.M.F. was applied to produce a steady current through the electrolyte. Caspari's results are therefore true overvoltages under the condition of indefinitely small current density.

b. The 'Knickpunkt' method.

This method was adopted by Coehn and Dannenberg and others, and consists in applying a gradually increasing potential to an electrolytic cell and observing the current which passes. At a certain potential, when decomposition sets in, the current increases very rapidly with slight increase of the applied potential. Hence the curve obtained by plotting current against applied potential bends sharply upwards and the position of the bend (Knickpunkt) gives the decomposition voltage of the electrolyte. The overvoltage of the cell as a whole is then found by subtracting the normal formation voltage of the decomposition products, and if one of the electrodes is unpolarisable, the overvoltage of the other is given. The method is unsatisfactory firstly, because it only can give information as to the overvoltage at indefinitely low current densities, and secondly because the exact position of the Knickpunkt is ill defined and very doubtful assumptions have to be made to decide on the voltage at which the curve really 'bends.' Consequently the method has given considerably varying results in the hands of different experimenters.

c. The bubble angle method.

This ingenious method was devised by Muller, who, starting from the conception that overvoltage was due to surface tension forces at the electrodes, attempted to measure it by determining the angle which the surface of a gas bubble makes with the electrode surface just before

liberation. This method is of course subject to the same limitation as those already given, *i.e.*, it can only be used with very low current densities. Also the fundamental assumption is not correct, for though overvoltage does depend partly on surface tension forces, there are other equally important factors which have to be taken into account. The results Muller obtained were similar to those obtained by Coehn and Dannenberg.

The following table shows some of the results obtained by these three methods, and will serve to illustrate the great differences of opinion held by different experimenters on this subject:—

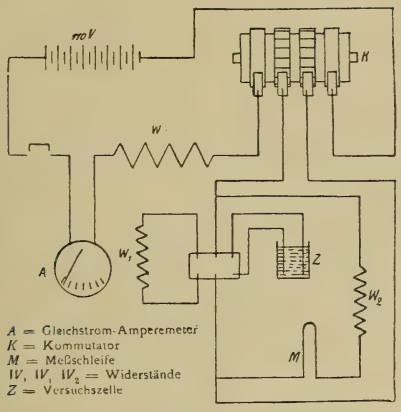
	Caspari.	Muller.	Coehn and Dannenberg.
Platinum	0·005 volt.	0·01 volt.	0·00 volt.
Gold	0·02 ,,	0·06 ,,	0·05 ,,
Silver	0·15 ,,	0·05 ,,	0·07 ,,
Nickel	0·21 ,,	0·03 ,,	0·14 ,,
Copper	0·23 ,,	0·03 ,,	0·19 ,,
Palladium	0·46 ,,	0·24 ,,	−0·26 ,,
Lead	0·64 ,,	0·35 ,,	0·36 ,,
Mercury	0·78 ,,	0·42 ,,	0·44 ,,

d. Oscillograph method.

This method was adopted by Le Blanc, Reichenstein, and others. The instrument used by Le Blanc consisted of a very sensitive moving coil galvanometer, having a coil and mirror together weighing only 0·5 mg., and

capable of recording vibrations as rapid as 6,000 per second. A pencil of light was focussed on the mirror and from thence on to a moving photographic film.

A diagram of Le Blanc's arrangement is given below.



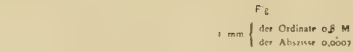
Text-fig. 2.

By means of the rotating commutator K, a current was sent through the experimental cell Z from the battery V for a certain interval, cut off for the same period, reversed and again cut off, etc.

The maximum current allowed to pass through the galvanometer was 0·01 amp., the fraction of the total current passing through the galvanometer being adjusted by means of the resistance W_2.

W_1 was an induction free resistance made equal to that of the experimental cell. The commutator was generally rotated at such a speed that there were 50—60 alternations per second.

When a metallic conductor was put in place of the electrolytic cell, the graph obtained on the photographic film was of the type shown in *Text-fig.* 3, which is taken from Le Blanc's book "Die Electromotorischen Kräfte der Polarisation."



Text-fig. 3.

With platinum electrodes in a solution of iodine in potassium iodide, a similar graph was obtained, showing that the velocity of depolarisation in this case was practically infinite.

With platinum electrodes in normal sulphuric acid, the graph obtained was of the type shown in *Text-fig.* 4.

Fig. 4 1 mm { der Ordinate 60,8 M. V.
der Abszisse 0,00068 Sek.

Pt | $\frac{n}{1}$ H_2SO_4 | Pt. Geschmirgelte Elektrode von 6 qcm Oberfl. Strom = 0,027 Amp. Widerstand des Nebenkreises 202,7 Ω Wechselzahl 56 pro Sek.

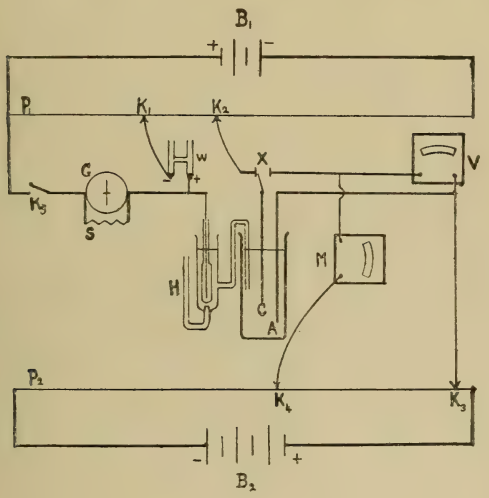
Text-fig. 4.

The actual potential of the platinum electrodes at any instant is shown by these curves. The slope of the curves is due, of course, to the gradual absorbtion of hydrogen and oxygen by the electrodes, and its disappearance by diffusion or re-combination. Hence these curves show not only the maximum E.M.F. from which the overvoltage can be calculated, but also the velocity of polarisation and depolarisation. The method, therefore, is of wide applicability but unfortunately fails in at least one important respect,—it cannot be used for determining the effect of passing the current for long intervals of time, and since this is essential for practical purposes, other methods must be used.

e. The back E.M.F. method.

This method was originally suggested by Le Blanc, and largely modified by Dr. Pring and the author of this paper.

The apparatus in its latest form is shown in *Text-fig.* 5.



Text-fig. 5.

The battery B_2 sends a current through the potentiometer P_2, and by means of movable keys K_3 and K_4 any required voltage may be tapped off and applied to the electrodes A and C through the milliammeter M. The voltage applied may be observed by means of the voltmeter V.

By means of a rapidly rotating commutator X, the cathode C is first connected to this source of current, and then the circuit is broken and the cathode at once connected with the potentiometer circuit P_1, the standard hydrogen electrode H being now the anode. The key K_2 is moved until no deflection is observed in the galvanometer G when the key K_5 is depressed, and this reading

compared with that obtained when K_2 is disconnected and K_1 depressed, K_1 being in connection with the standard Weston cell W.

Two points in connection with the commutator need special attention here.

The brushes on the commutator must make a clean sharp break in the primary current before connecting up the galvanometer circuit. Any drag in the break due to a loose wire in the brush will produce remarkable results in the measured overvoltage which may be highly misleading.

If the commutator is rotated at a speed greater than 1,000 per minute, no change is produced in the observed overvoltage by variation of the speed above this limit. At lower speeds, a slight fall in the observed overvoltage is produced with some metals, but in most cases it is not more than two per cent. lower at 500 revs. per min. than at 1,000 revs. per min. This is important as it shows that the fall of the back E.M.F. in $1/2000^{th}$ part of a minute is negligibly small under the given conditions. It was otherwise in Le Blanc's oscillograph experiments, owing to the fact that he not only cut off the current, but reversed it. Hence the accumulation of gas capable of setting up a long continued back E.M.F. was prevented. The conditions of Le Blanc's experiments are not present in regular electrolytic work, and therefore his results, though of great theoretical interest, are not likely to be of the same practical value as those obtained by the method just described.

Observations of the effect of much slower commutator speeds on the measured value of the back E.M.F. may give some useful information on the rate of depolarisation of the electrodes.

With this apparatus therefore, the true value of the

excess back E.M.F. or over-voltage is obtained, free from any complications due to internal resistance of the cell, gas films, etc. The relative positions of the electrodes in the cell is immaterial since no current is passing through the cell while measurements are being taken, and no current passes through the galvanometer when the key K_2 is in position.

By reversing the current through P_2 and P_1, anodic over-voltages may be measured in the same way.

The standard hydrogen electrode H_1 may be replaced by more convenient electrodes—calomel, mercurous sulphate, mercuric oxide, etc.—allowance being made for the difference of single potential in each case.

The experimental electrodes are best prepared from small strips or rods of metal, the surface of which is carefully cleaned with fine glass paper and coated with sealing wax or paraffin wax, leaving 1 sq. cm. only uncovered. The current density per sq. cm. is then obtained by doubling the reading of the milliammeter M, since the current is passing for only half the time.

2. Phenomena and Controlling Factors of Overvoltage.

The number and variety of the factors affecting over-voltage is so great that the merest outline of the most important is all that can be given here.

We may discuss them under three heads :—

a. In the electrodes—
- Nature of electrodes.
- Impurities in electrodes.
- Nature of surface.
- Previous history of electrode.

b. In the electrolyte—
Nature of ions present in electrolyte.
Concentration of electrolyte.
Impurities or additions to electrolyte.

c. General—
Current density.
Time.
External pressure.
Temperature.
Ionisation of gas liberated.

a. In the Electrodes.

The table of overvoltages already given is sufficient to show how greatly the metal chosen affects the magnitude of the overvoltage. Of the pure metals, platinised platinum has the lowest known cathodic overvoltage, and zinc or mercury under certain conditions the highest.

Slight impurities in a metal frequently produce great changes in the overvoltage. Scratching the surface of a lead plate with a platinum wire renders the plate useless as a cathode for powerful electrolytic reductions, while a trace of mercury covering an impure zinc plate raises the overvoltage sufficiently to prevent the zinc dissolving in dilute acid.

Hard forms of a metal have different overvoltages from soft forms, sometimes higher sometimes lower, so that hammering, tempering, annealing, etc., all exert a considerable effect on the overvoltage of some metals. This effect however usually disappears after the electrode has been in use for some time.

Generally speaking, rough surfaces show lower overvoltages than smooth ones but this is not always the case. A plate of polished lead when subjected to a high cathodic current density, becomes roughened, and at the same time

its overvoltage falls greatly. If the surface be roughened by making it the anode in dilute sulphuric acid for a short time and then reversing the current, its overvoltage rises to a very high value. Hence the *kind* of roughness of the surface as well as the nature of the surface itself may produce very great changes of overvoltage. Since the nature of the surface depends largely on the previous history of the metal, a knowledge of this is frequently of value in estimating the best conditions for attaining a certain overvoltage in electrolytic work.

It has long been known that the nature of the surface of the electrode affects the liberation of a gas from it, but only recently has it been shown that the converse of this is also true. When a polished platinum electrode is used as anode or cathode in dilute acid or alkali at high current density, its surface after a time becomes roughened, and if electrolysis is continued for a long period, a black coating is observed, which chemical tests show to be pure platinum. Other electrodes show similar behaviour and microscopic examination shows the presence of innumerable small craters, suggesting most forcibly that the surface has been blown open by a series of tiny explosions. See *Plate.*

b. In the Electrolyte.

The nature of the ion liberated at the electrode affects the overvoltage in much the same way as the nature of the electrode. If hydrogen is liberated at an electrode, its overvoltage will as a rule be quite different from that when oxygen or chlorine is being evolved. Platinum has a very high oxygen overvoltage but a very low hydrogen overvoltage. Nickel is low in both cases and lead high.

The overvoltage when a metal is depositing or being dissolved is, with rare exceptions, very small compared with that when a gas is being liberated.

When a given ion is to be liberated at a given electrode, the choice of electrolyte has comparatively little effect on the overvoltage so long as no chemical action takes place between the liberated ion and the electrolyte. Thus the cathodic overvoltage of most metals is nearly the same in N/1 H_2SO_4, N/10 H_2SO_4, N/1 NaOH, etc. As a general rule the overvoltages in the last electrolyte are slightly higher than those in the other two, but there are exceptions. Change of concentration of the electrolyte produces comparatively little change of overvoltage in most cases, but as a rule cathodic overvoltages are lower in more concentrated electrolytes. This is partly due to small concentration changes near the electrodes, and the difference therefore is less if the electrolyte is kept in motion. It is most marked in very dilute solutions, and since this concentration polarisation is not a part of true overvoltage, it should be avoided where possible by using fairly strong solutions.

Certain impurities in, or additions to the electrolyte produce marked effects upon the overvoltage, and in the case of metallic deposition, still more marked effects upon the nature of the deposit.

The presence of an oxidising agent such as chromic acid, permanganate, etc., reduces the cathodic overvoltage by assisting in the removal of the liberated hydrogen, and also by increasing its ionisation.

The action of colloids and poisons is remarkable. Generally speaking, small quantities of colloids (0·01 to 0·1 %) such as gelatine, dextrin, gum arabic, etc., increase the overvoltage of most metals by anything up to 0·1 volt. Larger quantities sometimes próduce still greater effects, but often produce no effect at all.

Thus 0·05 % dextrin raised the metal overvoltage of zinc by 0·04 volt, but had no effect on the hydrogen over-

voltage of lead, while 1·0 % of the same colloid had no effect on the overvoltage of zinc, but raised that of lead by 0·1 volt. Again 0·02 % gum arabic lowered the overvoltage of lead by 0·01 volt, while 4·5 % had no effect.

Poisons such as strychnine, brucine, nicotine, etc., sometimes raise and sometimes lower overvoltages.

It is evident, therefore, that no definite statement can be made as to the effects of colloids or poisons in general.

One point is, however, of interest here. The overvoltage of platinum is hardly affected by the presence of 0·05% gelatine at low current densities, but at higher current densities the overvoltage is kept practically constant, while without the colloid the overvoltage changes considerably. The colloid here appears to exert a stabilising effect, preventing the fall of overvoltage at high current densities—a phenomenon intimately connected with the concurrent lowering of the ionisation of the liberated gas.

The following table illustrates this :—

Current density per sq. cm.	Overvoltage.	
	With colloid.	Without colloid.
20 milliamperes	0·08 volt	0·06 volt
50 ,,	0·09 ,,	0·06 ,,
100 ,,	0·10 ,,	0·07 ,,
200 ,,	0·10 ,,	0·08 ,,
500 ,,	0·10 ,,	0·05 ,,
1,000 ,,	0·10 ,,	0·03 ,,
2,000 ,,	0·09 ,,	−0·03 ,,

The colloidal residue from aloes after the extraction of aloin is finding considerable application in electrodeposition of certain metals, as it tends in a high degree to induce the metal to form smooth coherent layers, instead of the rough uneven surfaces normally obtained. No parallelism has been found between this effect and the effect on the overvoltage.

When a metal such as lead has been used as electrode in an electrolyte containing a colloid which raises its overvoltage, it retains its raised overvoltage when washed with water and used in a pure electrolyte. Even lightly scraping the surface is not sufficient to destroy this high overvoltage, though heavy scraping does so at once. We are bound to conclude therefore that the colloid penetrates to an appreciable depth into the electrode surface, and it does not exert its full effect on the overvoltage until this penetration has taken place.

The following idea of the action of colloids during metal deposition may appear somewhat fantastic, but it certainly has the virtue of possibility.

Colloid molecules differ from others chiefly in their very high molecular weights, most of which are probably several thousand. As shown above, the ions by virtue of the attractive power of their electric charges, carry along with them some of these heavy molecules up to and into the metal surface. When these colloid carriers get near the electrode they will move much more slowly than free ions and will be thus under the influence of the electrical attractive force for a longer time. This will produce a high momentum in the colloid and carrier which will strike the electrode with considerable force. A continual hammering action by big molecules, which in many cases lose their carrying ion and rebound from the surface as soon as the ion gives up its charge, can well

produce the flattened polished surfaces which are obtained during metal deposition in presence of colloids.

c. General.

The effect of current density has been referred to several times already. It varies greatly with different electrodes and is sometimes so great that any statement as to the overvoltage of a particular metal is useless unless the current density is also stated. In the case of mercury the overvoltage may vary from a very high value, 0·7 volt, to a negative value, −0·05 volt, when the current density is raised from a low to a high value.

In almost all cases the overvoltage rises with the current density to a certain maximum and then falls with still greater current density.

The current density required to produce this maximum varies to a remarkable extent and is affected to a greater degree than overvoltage itself by the nature of the electrodes, impurities in the electrolyte, time, etc,, etc.

With some electrodes (Hg, Ag, W for example) it is difficult to apply a current density low enough to obtain the true maximum, specially when time effects are present; with others (gas carbon, amalgamated zinc, tantiron, etc.) the maximum is barely attained with the enormous current density of 200 amperes per sq. dm.

Generally speaking, the harder and the more porous the surface of the metal, the higher will be the current density required to produce maximum overvoltage, but this rule has exceptions.

The effect of time is similar to and largely dependent on current density.

The general rule to which there are few, if any, exceptions is that at low current densities the overvoltage increases with time up to a certain maximum and then

keeps more or less constant about that maximum. At higher current densities, it rises to a maximum and then falls to a more or less variable minimum. The time taken to reach this maximum varies from a few seconds to as many days, and is less with greater current density. The following table shows the variation in the overvoltage of a plate of polished platinum with time, the current densities being 300 mil. amps. and 400 mil. amps. per sq. cm. respectively. Platinum attains its maximum overvoltage with a current density of about 350 mil. amps. per sq. cm. under the conditions of the experiment so that one of the current densities used was a little below and the other a little above that necessary for producing the maximum.

	Volt.	Volt.
Overvoltage after 1 min.	0·076	0·060
„ 5 „	0·080	0·068
„ 15 „	0·088	0·092
„ 30 „	0·100	0·104
„ 1 hour	0·112	0·120
„ 6 „	0·173	0·236
„ 12 „	0·401	0·200
„ 24 „	0·511	0·120
After 5 mins. rest with no current ...	0·080	—
„ further 10 mins. with current...	0·122	—

After each series the platinum was examined under the microscope; in the first case it was hardly changed

in appearance, the surface being still bright and polished, but in the second case the surface was dull and the craters already referred to were clearly visible.

It would be difficult to obtain more conclusive proof than this of the fact that the ions of gas penetrate the surface of the electrode and set up great pressures within the electrode. If the current density is great enough, the internal pressures are sufficient to burst open the surface, thus releasing the compressed gas and lowering the overvoltage. If the current density, or rather the applied voltage, is not great enough to produce sufficient pressure to burst the surface, the gas accumulates in the metal and can only escape by re-dissolving in the ionic form. This it tends to do the more vigorously the greater the pressure, and hence the strong overvoltage. A rest for five minutes with no more ions pressing for admittance is sufficient to allow the greater part of this occluded gas to diffuse back into the solution, while a renewal of the applied E.M.F. rapidly sets up the high pressures again.

Considerations of this kind would lead to the conclusion that an increase of external pressure might alter over-voltage if only the pressure can be made great enough.

It is easy to calculate the effect of such pressures.

Let E = measured single potential of electrode liberating H_2.

E_o = normal potential of a H_2 electrode in same liquid.

Then by Nernst's well known formula

$$E = \frac{RT}{2F} ln \frac{K . p_{H_2}}{p} \qquad E_o = \frac{RT}{2F} ln \frac{K}{p}$$

where K is a constant, p the osmotic pressure of the hydrogen ions in solution, and p_{H_2} the pressure of the

gaseous hydrogen in the experimental electrode. (The pressure of hydrogen round the standard electrode is of course unity.)

Then the overvoltage

$$E - E_0 = \frac{RT}{2F} ln\, p_{H_2}$$

$$= 0{\cdot}029 \log p_{H_2} \text{ at } 18°C.$$

Hence for an overvoltage of 0·5 volt

$$0{\cdot}029 \log p_{H_2} = 0{\cdot}5$$

$$\therefore\ p_{H_2} = 4{\cdot}8 \times 10^{17} \text{ atmospheres.}$$

It is evident that a change of pressure of 100 atmospheres will produce a negligible effect upon such an electrode, a conclusion which is fully borne out by experiment.

Temperature has a relatively small but appreciable effect upon overvoltage, the rule being that rise of temperature decreases overvoltage. This effect has not been very fully studied, partly owing to the great difficulty in eliminating the effects of other confusing factors (time specially) while the temperature is changing.

Townsend (*Phil. Mag.*, 1898 [v], 45, 126) has shown that electrolytic gases carry with them a considerable electrical charge, and it is probable that this charged gas exercises an inductive effect upon the electrode. Gases may also be ionised by bubbling them through certain liquids, and the smaller the bubbles the greater the degree of ionisation. Thus hydrogen acquires a positive charge when bubbled through dilute acid by means of a very fine glass jet.

If hydrogen is liberated easily from an electrode of low overvoltage, one would expect the bubbles to be smaller than when it is liberated under higher pressure from one of high overvoltage, and further, that any

changes which tend to raise overvoltage will lower the ionisation of the escaping gas. All this is fully justified by experiment and it has been found that in all cases the overvoltage of a metal and the degree of ionisation of the gas liberated show an inverse relationship.[1] Since the pores in the metal are very much smaller than any which can be produced artificially, the ionisation of electrolytic gas is always much greater than that produced by bubbling through glass jets, etc. At high current densities the inductive effect is so great that in some cases the measured overvoltage is reduced to a negative quantity.

3. Theories of Overvoltage.

Sufficient has perhaps been said to show how complex a phenomenon that of overvoltage really is. We are probably dealing with a mixture of chemical, electrical, and mechanical forces, and a complete theory of overvoltage must take account of all.

The following outline of the chief theories so far suggested is given but it is impossible to do full justice to each theory in a paper of this type. For fuller information the references given at the end of this paper should be consulted.

Nernst considers that before a gas can be liberated from an electrode it must first penetrate into the metal which therefore occludes a certain amount of gas. If the solubility of the gas in the metal is small, the process of electrolysis must compress more gas into the electrode before it can be liberated. Hence the overvoltage should vary inversely with some function of the solubility. This theory fails to account for metal overvoltage, fall of overvoltage with high current density etc., but it certainly contains *part* of the truth.

[1] *J. Chem. Soc.*, **105**, 1914, 2428—2431.

Tafel also considers that the gas penetrates the electrode but further assumes that the formation of gaseous H_2 from $H^{\bullet}$ ions is a process requiring time. $H^{\bullet}$ ions (or atoms) will therefore accumulate at the surface of the electrode under pressure and tend to re-enter the solution thus giving rise to an excess back E. M. F. Some metals he considers exert a catalytic influence on the reaction $2\ H^{\bullet} = 2 \oplus + H_2$ and thus lower the overvoltage.

This ascribing of a 'catalytic' influence to the metals is not an explanation, but merely a substitution of one term for another, neither of which is understood. Hence this part of the theory has been passed over by most scientists, though an attempt has lately been made to revive it in America.

Böse assumes that the gas dissolves in the metal and is there dissociated into atoms which take on electrical charges. Particles of electricity are present in the form of 'neutrons,' $\oplus \ominus$, and the metal behaves as a solvent dissociating these and also the H_2. The free H then combines with a $+^{ve}$ charge forming ions which tend to pass into the electrolyte giving rise to an excess back E. M. F., *i.e.*, to overvoltage.

This theory is open to so many objections that it has received little or no support recently and is now practically abandoned.

Reichenstein considers that overvoltage is a measure of the difference between the rate of formation of ions and their disappearance by combination to form complexes or by other means. The ion, after giving up its charge, passes into a metastable form of gas or metal, which further changes to the stable form, each process

requiring time. Also the gases liberated penetrate to a definite distance into the electrode, and the product of this distance and the area of the electrode surface gives the "electrode volume." If this volume is great, the metastable particles take longer to come into contact with each other: hence the gas must accumulate to a greater extent and the overvoltage will rise.

This view is to some extent in opposition to that of Nernst, who considers that overvoltage is low when solubility of the gas is high.

The solubility of hydrogen is high both in platinum and palladium, specially in the latter where the electrode volume of a thin sheet is practically the volume of the sheet itself, while in metallic zinc it is very low. The overvoltage of platinum and palladium are normally very low but can rise to quite high values, while that of pure zinc is the highest of any single metal. These facts cannot be reconciled with Nernst's or Reichenstein's theories. Pring, by depositing films of metal of varying thickness on cathodes of different metals and measuring the overvoltage of the compound strip, was able to determine the approximate depth to which the hydrogen ions penetrate. His results were as follows:

In Pt	4×10^{-6} mm.	In Sn	$5{\cdot}5 \times 10^{-3}$ mm.
„ Au	$1{\cdot}6 \times 10^{-4}$ „	„ Ni	$1{\cdot}6 \times 10^{-2}$ „
„ Zn	$4{\cdot}2 \times 10^{-4}$ „	„ Pb	$6{\cdot}6 \times 10^{-2}$ „
„ Cu	$3{\cdot}4 \times 10^{-3}$ „		

The order in which these metals lie with regard to overvoltage is Pt Au Ni Cu Sn Pb Zn. Hence the order in which they lie with regard to electrode volume does not agree with the overvoltage order and the discrepancy is still greater if the actual values of the overvoltages be taken into account.

Like Nernst's theory, this probably contains a part of the truth.

Foerster suggests the formation of a solid solution or oxide or hydride on the surface of the electrode which would generate a high back E.M.F.

This theory, better than any other, explains the high anodic and low cathodic overvoltage of platinum but it is unsatisfactory in many important respects. This also may contain part of the truth.

Le Blanc suggests two factors to account for overvoltage.

1. The discharged ion does not separate at once but remains dissolved forming a supersaturated solution, increasing supersaturation producing increasing overvoltage.

2. The ions in the electrolyte are hydrated (combined with the solvent) and time is necessary for the reaction—ion hydrate $\rightleftharpoons$ ion + water—in both directions. Hence there will be excess or deficiency of non-hydrated ions near the electrodes which will also produce an excess back E.M.F.

Le Blanc thus locates the source of overvoltage in the electrolyte while Nernst, Reichenstein, etc., locate it in the electrode. Le Blanc's theory furnishes the most satisfactory explanation of metal overvoltage, but fails to explain the great influence of the nature of the electrode surface during liberation of gas. This again appears to contain part of the truth.

4. Suggestions for a Fuller Theory of Overvoltage.

The following are the most important known facts upon which the theory must be built.

1. Ions of gas-substance penetrate into the electrode surface, set up very great pressures which under certain conditions are sufficient to break open the surface, and also set up an excess back E. M. F which falls when the surface breaks.

2. Most of the ions in solution are either hydrated or at least are largely influenced by the neutral molecules round them.

3. In some cases certainly, in all cases probably, an alloy or solid solution is formed from the gas and the electrode material, which has a different single potential difference from that of the original electrode material.

4. Overvoltage and the ionisation of the escaping gas show an inverse relationship.

We may now picture to ourselves what goes on during electrolysis in the following way.

(i.) The ions have to pass through the series of changes

$$\underset{\text{Ion hydrate}}{a} \rightarrow \underset{\text{free ion}}{b} \rightarrow \underset{\text{free atom}}{c} \rightarrow \underset{\text{molecule}}{d}$$

and molecules, the same series in the reverse order.

Of these changes, *b*—*c* takes place at the moment of electrical contact of the ion with the electrode. The other two require a measurable time, and hence there may be produced an excess or deficiency of *b* and *c* in the electrolyte and at the electrodes respectively, which gives rise to overvoltage. This effect will be proportional to the current density and occurs with all ions, gaseous or metallic. It is the sole cause of metal overvoltage, but is never very great, since metal overvoltages are small compared with gas overvoltages.

(ii.) When the current is first applied, the outer surface of the electrode will rapidly become covered with new

free atoms and molecules. If these are gaseous, they will be held against the electrode surface partly by the attraction of the metal due to its electrical charge and partly by the pressure of incoming ions. The latter will find the nearest portions of the electrode already occupied, and therefore will have to get further and further in to the electrode before finding a vacant spot where they can make electrical contact and give up their charges.[2] When they have given up their charges they will unite to form molecules and then escape as they are knocked off by the general disturbance taking place.

The electrode surface probably compares with an ion much as a bundle of sticks or a pile of loose stones does with a bullet. Hence there will be many cases where ions will enter a hole too small to allow molecules to escape. Enormous pressures are thus set up by the imprisoned molecules which can only escape by re-ionising or breaking the metal surface. The deeper the hole, the greater the pressure. The overvoltage of an amalgamated zinc cathode in dilute sulphuric acid can rise to over 0·87 volt under certain conditions. The calculated pressure to produce this is 10^{30} atmospheres. While it is evident that the pressures in the electrode are very great, such a pressure as this passes the bounds of credibility. It is necessary therefore to consider further what happens to the gas at the electrode before it is liberated.

(It has of course been assumed that hydrogen behaves as a perfect gas, an assumption which cannot be true at

[2] Rapid stirring of the electrolyte reduces overvoltage considerably by 'brushing' away some of the adhering surface gas. Also during overvoltage measurements, cases are frequently observed where the overvoltage remains perfectly steady but the current passing through the experimental cell is erratic, the jerky variations being sometimes greater than 10% of the main current although the applied E.M.F. is quite constant. This variation of *resistance* between the electrode and electrolyte is evidently due to disturbances in the gas film adhering to the external surface of the electrode.

such high pressure. Also the fraction of the overvoltage produced according to Le Blanc's theory has been neglected, but even when these things are taken into account, the pressures we must assume are still incredibly high).

(iii.) When hydrogen is bubbled round a palladium plate in dilute acid, an alloy or solid solution is produced having a single potential quite different from that of the pure metal. If the same plate is treated cathodically, still more hydrogen is absorbed and the potential may rise 0·5 volt if the current density is kept low. Platinum behaves in much the same way. It seems more than probable therefore that this is true to a greater or less extent with all metals and that part at least of the measured overvoltage is due to the high single potential of an alloy formed on the surface by the discharged ions (free atoms) uniting with the electrode material. This alloy is of course super-saturated with gas which is continually endeavouring to form another alloy of still higher gas content.

When this alloy is prepared with hydrogen at normal pressure, its potential must be the same as that of a hydrogen electrode in the same liquid, for if it were not, then a current could be obtained capable of doing work by hydrogen dissolving at one electrode and being liberated at the other. Since the same quantity of hydrogen is involved in each case, the process could go on in an isolated system, and perpetual motion would be obtained.

When the alloy, already saturated with hydrogen at normal pressures, is further treated with gas at higher pressures, other alloys of greater hydrogen content will tend to form, and these will have potentials which cannot be calculated from the gas pressures by Nernst's equation, since the concentration of the hydrogen is not proportional to the pressure.

The hydrogen in the alloy is probably in the monatomic condition, as has been proved in the case of palladium,[3] and this would explain the so-called catalytic effect of palladium, platinum, etc., in promoting the combination of hydrogen and oxygen. When the current is stopped, the alloy will tend to decompose spontaneously, thus liberating gas within the electrode, which will further increase the pressure beneath the surface.

In the case of anodic overvoltage, which can rise to much greater values than cathodic, the alloy or solid solution is probably formed in many cases, not from the gas itself but from a compound of the gas and the electrode material. With certain metals, the presence of the alloy produces passivity.

(iv.) Lastly, when the gas comes out of the electrode in the form of a tiny bubble, it acquires an electrostatic charge on its surface as soon as it comes into contact with the electrolyte. This charge is very close to the electrode and therefore acts inductively on the electrode reducing the measured overvoltage. The reduction is directly proportional to the current density and also varies inversely with the size of the escaping bubbles. Experiment shows that the size of the bubbles varies with the electrode chosen but is practically constant with a given electrode. Hence at high current density there may be a considerable lowering of the overvoltage from this cause, in fact with platinum and mercury the overvoltage can be reduced to a negative quantity at very high current densities.

An interesting experiment which serves to confirm some of these views was made with a mercury electrode 1 sq. cm. surface area. This was used as cathode in N/1 H_2SO_4 for a short time until its overvoltage was 0·6 volt.

[3] Winklemann: *Drude's Ann.*, **6**, 104 (1901).

The current was then cut off for half a minute to allow surface hydrogen to escape by diffusion, and the electrode then connected with a mercurous sulphate electrode through a galvanometer reading 10^{-6} ampere. A current of 30×10^{-6} amp. passed at first and fell rapidly, but after 20 mins. was still 2×10^{-6} amp. This means that about 10^{-2} coulombs was given by the hydrogen alloyed with the mercury, or about 1 cu. mm. H_2 per sq. cm. of surface. A similar experiment with two copper electrodes gave a still higher result, the current remaining at 30×10^{-6} amp. even after the electrodes had been taken out of the liquid, replaced, and short circuited for 20 seconds. Further experiments on these lines will be carried out later.

A strip of thin sheet-iron when used as cathode in dilute sulphuric acid becomes much stiffer and almost brittle. When used as anode in the same liquid, this stiffness disappears and the metal becomes very soft and pliable. This again suggests alloy formation on the surface.

Electrolytic oxidations and reductions may be produced (i.) by the action of the electrode alloy, (ii.) by the action of the discharged ion, (iii.) by the action of electricity itself.

(i.) is evident from the fact that in cases where the alloys are obtainable in the free state, they are able to produce similar effects to those obtained electrolytically. Thus palladium-hydrogen or platinum-hydrogen alloys combine directly with free oxygen giving water and the free metal. Also platinum oxide is a very powerful oxidising agent and is probably formed at a platinum anode giving rise to the very high anodic overvoltage of 0·86 volt.

(In *J.C.S.*, **105**, 1914, 2422 and 2423, the anodic overvoltage of platinum is given as 0·56 volt. The error was not observed until after the paper was printed).

As the composition of the alloy varies, its back E.M.F. will also vary, and hence the most powerful oxidising or reducing action will be exerted when this back E.M.F. is greatest, *i.e.* when the overvoltage is greatest. Part of the fall of overvoltage at very high current densities is also due to this variation of the composition of the alloy, since one with very high gas content may have a lower back E.M.F. than one with less gas.

(ii.) is probably the main source of high-efficiency oxidations and reductions. When an easily oxidisable or reducible body is present, the discharged ions react at once before time is given to form a higher alloy or produce any appreciable pressures in the electrodes. Hence the presence of these bodies will reduce the overvoltage to an extent dependent upon the speed of the secondary reaction, a conclusion fully proved by the extensive researches of Le Blanc.

(iii.) only occurs when the oxidisable or reducible body is itself ionised or capable of being ionised. It is, however, of very common occurrence : thus copper sulphate is reduced to metallic copper by adding a negative or subtracting a positive charge from the copper ion ; ferrous sulphate is oxidised to ferric sulphate by adding a positive charge to the ferrous ion, etc.

Summary.

The following suggested theory of overvoltage is composed of parts of the theories of Nernst, Le Blanc and Foerster, with additions.

The overvoltage of a metal is determined by four factors.

1. Supersaturation of the electrode surface with non-electrified gas under very high pressure, due to the permeability of the metal to the ionised gas, but non-permeability to the molecular, and also to the spontaneous decomposition of the alloys containing the same gas.

2. Formation of a series of alloys or solid solutions of gas (or gas + electrode – material compound) with the electrode surface.

3. Deficiency or excess of non-hydrated ions, charged and discharged, in the immediate neighbourhood of the electrodes.

4. Inductive action of the escaping ionised gas on the electrode.

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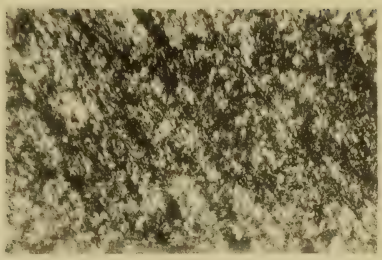
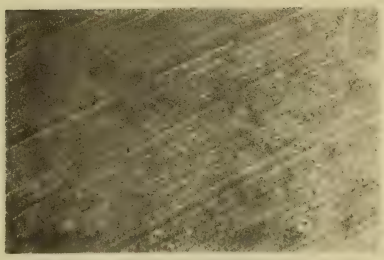
Zinc before.



Zinc after.

Copper before.



Copper after.

Platinum before.

Platinum after.

Microphotographs of metal cathode plates before and after electrolysis with a current density of 1 ampere per sq. cm. for two hours. Magnification 320 diameters.

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XII. The Geographical Distribution of the use of Pearls and Pearl-shell.

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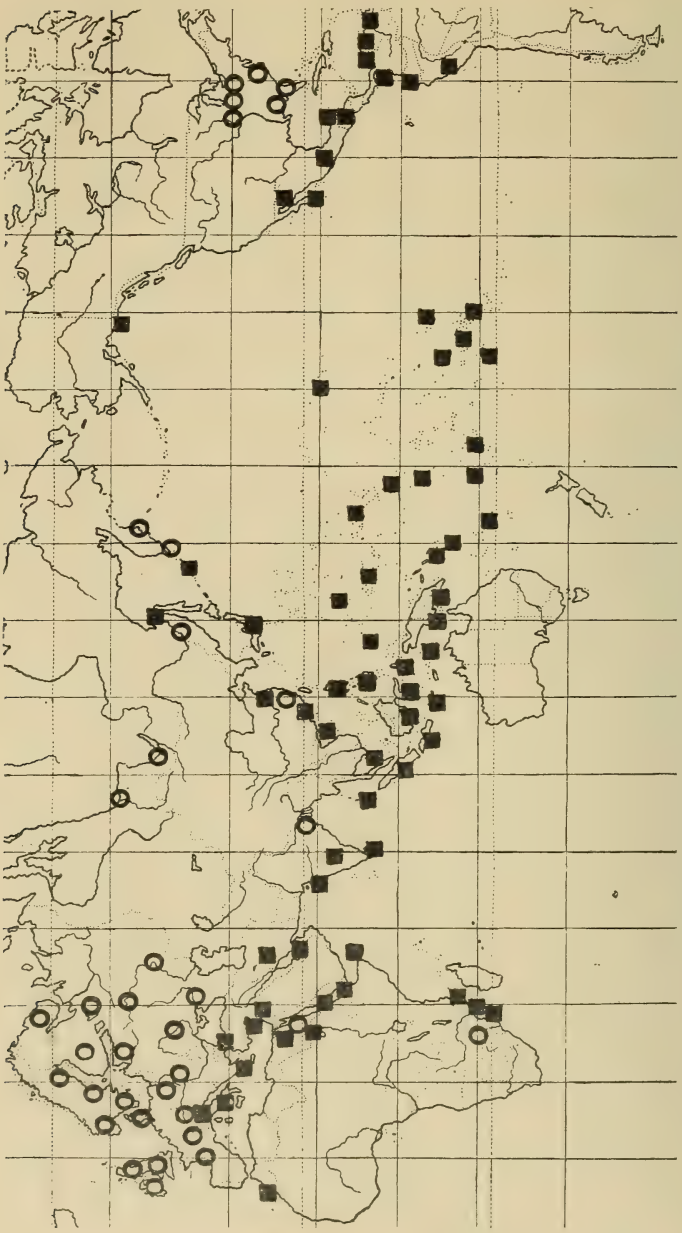
For many centuries pearls have been objects of commerce between nations, and from their peculiar beauty and splendour they have been held in high estimation among many peoples, civilised and barbarian. Superstitious reverence in one form or another has also been accorded them, and they have been considered as symbols of purity, beauty, and nobility, besides being regarded as emblematical of conjugal bonds. More curious still is the fact that for ages pearls or pearl-shells have been supposed to possess valuable medicinal qualities, and have been used in medicine, either as a powder or as one of the chief ingredients of pills, especially in Oriental countries.

Regarding the origin of pearls many wild and extravagant ideas have been advanced in the past by different peoples, one of the most curious of these notions being the belief that they were formed from drops of rain falling into the gaping valves of the pearl-shell. This "congealed dew-drop" theory is remarkable for its wide distribution. It was current among the ancient people of



Map showing distribution of the Use of Pearls and Pearl-shell.

O = Freshwater. ■ = Marine.

the Mediterranean, spreading from there to India, China, and other places, and was found by Columbus to exist among the inhabitants of the New World.

In previous papers attention has been called to the intimate association which exists between the special appreciation of pearls and the geographical distribution of elements of a culture, including amongst other things, the use of shell-purple for dyeing, and of conch-shells for trumpets. The evidence concerning the spread of these latter cultural elements has already been given,[1] and the object of this paper is to present some of the facts connected with the distribution of the use of pearls and pearl-shell.

The remarkable manner in which the sources of pearls and pearl-shell coincide with the distribution of megalithic structures has been emphasised by Mr. W. J. Perry in his recently published paper on "The Relationship between the Geographical Distribution of Megalithic Monuments and Ancient Mines."[2] Some further facts in justification of this are included in the present communication.

When the fashion for pearls and pearl-shell was first instituted is not known, but the available evidence suggests that it originated somewhere in the vicinity of Egypt, if not in Egypt itself. From this centre the fashion spread to surrounding nations of antiquity, and at a later time, together with an extraordinary collection of fantastic practices and beliefs, it was carried far and wide, eventually reaching the Far East, Oceania, and the New World. Phœnician influence was undoubtedly largely instrumental in the distribution of the appreciation of the pearl, and in the course of trade these ancient mariners inaugurated extensive pearl-fisheries in many of the places

[1] *Manch. Memoirs* (Lit. & Phil. Soc.), vol. lx. (1916), Nos. 7 and 8.

[2] *Manch. Memoirs* (Lit. & Phil. Soc.), vol. lx. (1915), No. 1.

they visited. Not only were the highly-prized marine pearls sought for, but also those from the freshwater pearl mussels of the family Unionidæ.

The Red Sea is probably the most ancient of the known sources of pearls. Gems from this neighbourhood were known many centuries before the Christian era, and the fishery was in a flourishing condition in the time of the Ptolemies. These pearls are referred to by Strabo, Ælianus, and other classical writers.[3] The most interesting feature in connection with these fisheries is the fact that the ancient inhabitants of the shores of the Red Sea were acquainted with an artificial method of producing pearls. According to the philosopher Apollonius,[4] the inhabitants rendered the sea smooth by flooding it with oil; they then dived into the sea and halting alongside the pearl-oyster they induced it to open by holding out a case of myrrh before it as a bait. The oyster was then pierced with a long pin and the liquid which exuded from the wound was received into an iron block which was hollowed out in regular holes, where it petrified in regular shapes, just like the natural pearl. Though the details as to the method of procedure are scarcely credible, it is not improbable that the story has some sound foundation, and that attempts were really made at that early time to stimulate the growth of pearls. This interesting fact is of some importance in connection with the artificial production of pearls in India and China, to which attention is called on later pages.

From the proximity of the Red Sea to Egypt it is not surprising that the pearl-shell was known to the Egyptians

[3] Kunz and Stevenson, "The Book of the Pearl," *New York, 1908*, pp. 139 *seq.*

[4] Philostratus, "The Life of Apollonius of Tyana," bk. iii., ch. lvii. (Edit. Conybeare, vol. i., 1912, p. 343).

at a very early period in their history. In their search for the Red Sea cowries, and other shells, used as desirable objects for placing in the graves of the dead in Pre-dynastic and later times, they must have soon become familiar with the mother-of-pearl shell.[5]

According to Kunz and Stevenson (*op. cit.*, p. 6) the pearl-shell was in use as an ornament in ancient Egypt as early as the VIth dynasty. In investigating the ruins of ancient Thebes, Dr. J. T. Dennis discovered several of these shells bearing cartouches of that period. In graves of the XIIth dynasty, Red Sea pearl-shells have been found engraved with the name of Senusert I.[6] These shells are perforated with two holes for wearing as a pectoral pendant, as in the Pacific Islands and elsewhere. In the 'pan graves' of the same period, mother-of pearl bracelets occurred made of narrow strips of shell, perforated at each end and threaded together, thus forming a flexible band.[7] Similar discoveries have been made in Nubia.[8]

The presence of the marine pearl-shell in Egypt has been looked upon by some authorities as indicating an early trade with India. On this point Lacouperie[9] remarks: "Commercial relations between the Kushite emporia of South Arabia, the West coast of India, and

[5] It is of interest to note that the use of cowries is intimately associated with that of pearls in most of the area occupied by the megalithic culture.

[6] W. M. Flinders Petrie, "Amulets," London, 1914, p. 27, pl. xliv., fig. 112*a*. An exactly similar specimen, engraved with the same name, from Rifeh, 1907, is in the Manchester Museum.

[7] W. M. Flinders Petrie, "Diospolis Parva, The Cemeteries of Abadiyeh and Hu, 1898-9," 1901, p. 46, pl. xl.

[8] G. A. Reisner, "The Archæological Survey of Nubia." Report for 1907-08, vol. i., Archæological Report, Cairo, 1910, p. 54, pl. 70*b*.

[9] T. de Lacouperie, "Western Origin of the Early Chinese Civilisation," London, 1894, pp. 97-98.

the South as far as Ceylon, were perhaps already opened at the time of the XIIth dynasty of Egypt." But, he goes on to say, "the proof is not above suspicion. It consists of a shell of mother-of-pearl, such as those of Ceylon, which, inscribed with the cartouche of Usurtasen, was bought in Egypt in 1883 by Professor Sayce. It may have been engraved long after the reign of that sovereign." There is no reason, however, to doubt the authenticity of this specimen in the light of the more recent discoveries mentioned above, but the evidence of its Ceylon origin is untrustworthy. As the same species of pearl-shell inhabits the Red Sea, it is more probable that this was its true source.

In addition to the mother-of-pearl shell, pearls themselves were used by the Egyptians, though from an examination of representations of the costumes of ancient Egypt, they do not appear to have been employed to any great extent in their decorations.[10] They are represented on old Egyptian monuments, and diadems of pearls have been found from time to time in ancient sarcophagi. From about 1500 B.C. Egyptian women wore earrings, generally simple loops of gold, from which hung pendants of precious stones and pearls. They, likewise, wore necklaces made of alternate rows of shells (cowries, etc.), coral, scarabei, precious stones and pearls. One ornament worn by both sexes was the gorget, upon which pearls were embroidered in elaborate patterns.[11] It was not, however, until after the Persian conquest in the fifth century B.C. that pearls were used extensively.[12]

The Egyptians were also familiar with their own local

[10] Kunz and Stevenson, *op. cit.*, p. 6.

[11] E. W. Streeter, "Pearls and Pearling Life," London, 1886, pp. 33-34.

[12] Kunz and Stevenson, *op. cit.*, p. 6.

freshwater pearl mussels, *Aetheria* (Nile oyster), *Unio*, etc. at a very early period, using their valves as receptacles for paints, etc., in Pre-dynastic and later times. Whether they obtained pearls from these is not known, but the pearly nature of the shells themselves may have led to their being objects of appreciation. The *Aetheriæ* occur in the Nile as high as the cataracts of Robâtâs in Upper Nubia, and are described by Cailliaud, in his "Voyage à Méroé," as being a common article of food. Their shells are collected by the natives in order to decorate the tombs of deceased relatives.[13] Perforated discs of this shell were found in some numbers in a tomb of the XVIIIth dynasty (grave D 114) at Abydos,[14] but whether they were used for ornamental purposes, such as necklaces or armlets, is difficult to decide. Judging from their size (diam. 27 mm.) they would not prove suitable objects for this purpose. There is no evidence to suggest that they were employed as a form of currency.

Beyond the reference by Pliny[15] to pearl fisheries on the Mauritanian coast—probably inaugurated by the Phœnicians, who visited West Africa for gold—little is known of the use and exploitation of pearls in this part of Africa.

On the east side of the African continent, pearl fisheries are known south of the Gulf of Aden. According to Kunz and Stevenson (*op. cit.*, p. 153) "little information exists as to the origin of these fisheries. In a paper published by the Lisbon Geographical Society, January, 1903, Señor Ivens Ferranz states that, according to tradition, in remote times the Ibo Archipelago, on the

[13] Mary Roberts, "Popular History of the Mollusca," 1851, p. 311.

[14] T. Eric Peet and W. L. S. Loat, "The Cemeteries of Abydos," pt. iii., 1912-13. 35th *Mem.* of *Egypt Explor. Fund*, 1913, p. 30, pl. xii.

[15] Pliny, "N.H.," bk. ix., ch. 56.

north-east coast of Portuguese East Africa, was inhabited by a Semitic colony, which located there to fish for pearls, and these were carried through the Red Sea to King Solomon. He adds that there is little doubt that, after the great emigration which started from the Persian Gulf in 982 and founded Zanzibar, Kilwa, and Sofala on the coast, some Arabs engaged in fishing for pearls about the islands near Sofala."

The evidence of early pearl fishing on the coast of East Africa is significant in view of the implied association between megalithic culture and pearls. In the map which illustrates Mr. Perry's paper (*op. cit.*, p. 10), the presence of the pearl-shell is not indicated on the coasts of Zanzibar and Madagascar "two localities which are suggestive when the presence of megalithic monuments in Rhodesia and Madagascar is recalled" (p. 11). Another important link is afforded by the discovery of beads made from the shell of the common Unio or fresh-water mussel (*Unio verreauxi*) in graves in the vicinity of Bulawayo, Rhodesia.[16]

The Persian Gulf has been famous as a source of pearls from ancient times. A very early origin of pearl fishing here seems to be indicated by a cuneiform inscription on a broken obelisk, erected presumably by a king of Nineveh, which has been translated by Jules Oppert, the eminent Assyriologist.[17] The fisheries were well known in the time of Alexander, and are referred to by Pliny[18] as yielding the most valuable pearls. Isidorus of Charace, a Greek historian, *circa* 300 B.C., mentions the pearl fishing in this neighbourhood in his account of the Parthian Empire, and gives a fanciful story of the influence of thunderstorms on the breeding of pearls.[19]

[16] Kunz and Stevenson, *op. cit.*, p. 513.

[17] *Ibid.*, p. 85.

[18] Pliny, "N.H.," bk. ix., ch. 54.

[19] Athenæus, "Deipnos," bk. iii., ch. 46.

The inhabitants of the Island of Bahrein—the Tylos of Ptolemy—have been devoted to pearling from time immemorial, and the fishing to-day is carried on much as it was 2,000 years ago. This island was in touch with Chaldean civilization, and one of the traditional sources of the Phœnicians, and whence came that fish-god who—according to the Babylonian myth—bore the ark over the deluge.[20]

In Persia, pearls were almost certainly known in the seventh century B.C.; they are not mentioned in the extant fragments of ancient literature, but pearl ornaments of great antiquity have been found among Persian remains. Assyrian and Persian bas-reliefs show that pearls were used profusely for adornment by the sovereigns and great personages of those countries. The portraits of Persian queens on coins and gems commonly show ear-pendants of pearls.[21] Portraits of Sassanian kings show a pearl pendant of large size hanging from the right ear, and among Persian nobles it was the custom to wear in the right ear a golden ornament containing pearls. The women also wore a ring through the left nostril, upon which three pearls were strung, and round their heads was a band with pendant jewels or pearls. The kings of the Medes and Persians wore bracelets and necklaces of pearls, and these gems were employed lavishly in their trappings and equipages. At the present time pearls play a prominent part in great festivals in Persia.[22]

Among the ancient Persians a solar origin was attributed to the pearl.[23]

Babylonian dignitaries and priests, it is stated, wore

[20] Kunz and Stevenson, *op. cit.*, pp. 90 *seq*

[21] *Ibid.*, pp. 5 and 404.

[22] Streeter, *op. cit.*, pp. 30-31.

[23] *Ibid.*, p. 48.

strings of pearls, most of which no doubt came from the Persian Gulf fisheries.[24] In the ruins of Babylon, however, no pearls have been found ; the relatively moist soil containing much saltpetre may account for their non-survival for so many ages.[25]

According to Kunz and Stevenson (*op. cit.*, p. 405), one of the most interesting examples of the use of a pearl in ancient times is a beautiful prehistoric pearl pin from Paphos, on the Island of Cyprus, which is mounted with a large marine pearl measuring 14 mm. in diameter, and weighing about 70 grains. It is surmounted by a small fresh-water pearl 4 mm. in diameter.

In excavations made in the Huaran district in Syria, a number of pearls were found in a rock-cut tomb said to be of Roman origin. The pearls were still attached to a bronze wire with which they had been strung. A pearl pin and a single earring bearing a pearl have also been recorded from a rock-tomb at Cæsarea, in Syria.[26]

Pearls were esteemed by the Greeks in the time of Homer, who appears to allude to them under the name τρίγληνα (triple drops or beads) in his description of Juno, in the Iliad, xiv., 183 ; and in the Odyssey, xviii., 298. Classical designs of Juno usually show the three pear-shaped pearls pendent from her ears. The pearls of the ancient Greeks were obtained probably through the medium of the Phœnicians, and during the Persian wars of the fifth century B.C., they doubtless extended their acquaintance with these beautiful gems.[27]

The necklaces and earrings, on the heads of female divinities, goddesses, and nymphs, represented on Greek coins from the fifth century B.C., are considered by many

[24] *Ibid.*, p. 31.

[25] Kunz and Stevenson, *op. cit.*, p. 5.

[26] *Ibid.*, p. 406.

[27] *Ibid.*, p. 8.

numismatists to be intended to represent pearl ornaments.[28]

Theophrastus, writing about 300 B.C., mentions the gems, and describes them as the product of shell-fish. In his day they were valued for necklaces or bracelets. Pliny also refers to other Greek writers on the subject. Like the Persian nobles, Grecian men of rank wore one pearl earring in the right ear, while the women wore one in each ear.[29]

Interesting evidence of the ancient appreciation of pearls in the neighbourhood of the Crimea is furnished by the discovery of gold earrings with pearl centres, probably of the first half of the third century A.D., in a tomb close to the site of the ancient town of Chersonesus, and of earrings and pins set with pearls, from the neighbourhood of Tiflis. An earring of fourth century date made of gold wire, on which seven pearls are threaded, said to have been found on the site of the ancient Greek colony of Olbia, is of special interest in view of the fact that the pearls are drilled. Another interesting find, also of the 4th century A.D., is that of a brass dress pin with a sphere of amber, surmounted by a pearl, found near the village of Mzchet Caucasus.[30]

The custom of wearing a ring, ornamented with corals, pearls or precious stones, was prevalent among the fashionable Tartar ladies of Astrakhan, in the 18th century. This was worn suspended from the perforated right nostril, and recalls a similar practice among the women of Persia (supra, p. 9).[31]

[28] *Ibid.*, p. 409.

[29] Streeter, *op. cit.*, p. 35; Kunz and Stevenson, *op. cit.*, p. 8.

[30] Kunz and Stephenson, *op. cit.*, p. 410.

[31] G. A. Cooke, "System of Universal Geography," London (1801), vol. i., p. 448.

From Greece the admiration for pearls spread to Rome, where they were known under the Greek word *margaritæ*, as well as the Roman name *unio*. According to Pliny (bk. ix., ch. 59), the Romans used the latter name to distinguish a pearl of remarkable size. This celebrated Roman naturalist, who regarded pearls as formed by dew or rain falling into the gaping shells of the pearl-oyster,[32] tells us that after the surrender of Alexandria, these gems came into common, and indeed universal, use at Rome; but they first began to be used there during the Jugurthan wars.[33]

The Romans were deeply affected by pearls, and these gems took precedence over all others. Roman ladies wore necklaces and ear-drops of pearls, and dresses were lavishly covered with these gems. They were worn even at night that in their sleep the owners might be conscious of the possession of such valuable jewels. Pliny[34] gives us a graphic description of the pearls and other ornaments worn by the Roman empress Lollia Paulina at an ordinary wedding entertainment. It was not unusual for the Romans to adorn their horses and other favourite animals with splendid necklaces; and it is said that "Incitatus," the favourite horse of the Emperor Caligula, wore a pearl collar. Pearls also decorated the altars in the Roman temples, and the furniture of the houses, while their war-chariots shone with them. Philo Judæus speaks of the couches upon which the Romans reclined at meal-times as being ornamented with tortoise-shell and ivory, and shining with gold and pearls. He also adds that upon the couches lay purple coverings embroidered in gold or pearls. Under successive emperors sumptuary laws were

[32] Pliny, "N.H." bk. ix,, ch. 54.

[33] *Ibid.*, bk. ix., ch. 59.

[34] *Ibid.*, bk. ix., ch. 58.

issued in order to stem the tide of extravagance which threatened the ruination of all classes. Julius Cæsar issued an edict, prohibiting the use of purple and pearls to all persons who were not of certain rank, and the latter also to unmarried women.[35]

The mother-of-pearl was evidently appreciated in Northern Italy long anterior to the time of the Roman Empire, as the shell of the pearl-oyster of Eastern seas has been found in ancient hut foundations, reported to be of Neolithic age, near Reggio Emilia.[36] This discovery would seem to indicate very early intercourse with the advanced culture of the East. Further evidence in support of this is furnished by discoveries of conch-shell trumpets and broken *Purpura* shells in Ligurian caves, to which attention has been called in earlier papers read before this Society (see footnote 1.).

It is probable that the ancient Hebrews valued pearls for ornamental purposes, doubtless obtaining them by commerce with the Phœnicians. It is remarkable, however, that the Hebrew word, gâbish, translated "pearl," occurs but once in the Old Testament. Some doubt exists even here as to the true significance of the word, some writers claiming that it relates to some other substance, probably "crystal." In the New Testament and in the Talmud are to be found frequent references to pearls, which show how these gems were estimated by the Jews. Mother-of-pearl is still a commodity of general traffic in Palestine, where it is carved by the inhabitants into various religious ornaments.[37]

[35] Lovell, "Edible British Mollusca," 1884, p. 92; Streeter, *op. cit.*, pp. 39-40; Kunz and Stevenson, *op. cit.*, p. 9.

[36] Mosso, "The Dawn of Mediterranean Civilization," 1910, p. 269, quoting Colini, *Atti della Società romana d'Antropologia*, vol. x., 1904.

[37] Streeter, *op. cit.*, p. 32; Kunz and Stevenson, *op. cit.*, pp. 6-7.

Although the pearls used by the ancient people of the Mediterranean were largely those obtained from the true pearl-oyster, pearls from other sources seem also to have been employed. Pliny[38] informs us that they used formerly to be found in the seas of Italy, but more frequently about the Thracian Bosporus; they were of a red colour, and small, and enclosed in a shell-fish known by the name of "mya." Off the coast of Acarnania they were obtained from a shell-fish called "pina,"[39] but the pearls were ill-shaped, and of marble hue; those found about Cape Actium were better, though of small size.

Pearls have been associated with the name of Britain from very early times. According to Suetonius, the great motive of Cæsar's expedition into Britain in 55 B.C. was to obtain its pearls, which were so large that he used to try the weight of them by his hand. Pliny[40] confirms this, saying that Cæsar dedicated a breastplate covered with British pearls to Venus Genetrix, and hung it in her temple at Rome. The British pearls, doubtless obtained from the fresh-water pearl-mussel, *Margaritana margaritifera*, seem to have been regarded by ancient writers as dull in colour and lustre and inferior to the pearls of the Orient.

The imperial diadem of the sovereigns of the ancient Britons, Whitaker remarks, was sometimes encircled with an ornament of the mussel-pearls, as appears from the coins which have come down to us.[41]

That the pearl or pearl-shell was appreciated by the inhabitants of Britain as early as the Neolithic age seems

[38] Pliny, "N.H.," bk. ix, ch. 56.

[39] Pearls are frequently obtained from the *Pinna*-shell at the present day.

[40] Pliny, "N.H.," bk. ix., ch. 57.

[41] Whitaker, "History of Manchester," 2nd ed., London, 1773, vol. i., pp. 22 and 342.

very probable from the discovery of the shell of the fresh-water pearl-mussel (*Margaritana margaritifera*) associated with human remains in the sepulchral cave at Perthi Chwareu, near Llandegla, Denbighshire.[42]

The presence of fragments of pearl-shell in the paste of early hand-made pottery may also be an indication that the Early Britons considered the shell as auspicious and consequently adding further value to their product, analogous to the use in India of lime obtained by burning both chank and pearl oyster shells. It is significant how widely spread are both these customs. The shells of *Unio* are recorded from North American Indian graves where they had been placed to serve as food for the dead during the journey to the land of spirits ; and fragments of *Unio* shells were used by the Indians to temper the clay for pottery. Beads of *Unio* shell have also been found in graves in the neighbourhood of Bulawayo, Rhodesia, as already stated.

An interesting survival of the Greek word τρίγληνα (triple drops or beads, *i.e.*, pearls) seems to exist in the Welsh *glain* (bead), the name having been carried to Britain by Phœnician traders.[43] It is well known that the Phœnicians, after founding many colonies in the Mediterranean, passed on through the Straits of Gibraltar, and in course of time probably reached the British Isles. Here no doubt they became acquainted with the pearls of the British rivers.

The principal fresh-water pearl fisheries in the British Isles are those of the Conway River, in North Wales, where it is supposed Cæsar obtained his pearls ; the Irt, in Cumberland ; the Tay, Earn, and Teith, in Perthshire ; the Dee, Don, and Ythan, in Aberdeenshire ; the Spey

[42] J. W. Jackson, *Lancashire Naturalist*, Dec., 1913, pp. 321-2.

[43] Kunz and Stevenson, *op. cit.*, p. 8.

and Findhorn, in Inverness-shire; and the rivers of the counties of Kerry, Donegal, Tyrone, Wexford, etc., in Ireland. These fisheries have been described by many writers from the time of the Venerable Bede (673—735 A.D.) to the present day, and allusion has been made to the prevalent belief in the dew-drop origin of the gems.

On the continent of Europe the abundance of pearls in the mussels of the lakes and rivers has also given rise to many important fisheries. Little is known, however, of their early history, except that some of these localities appear to have been exploited by the Romans. It is probable that some are of an even earlier date, possibly owing their inauguration to Phœnician influence, as in the British Isles.

The principal areas where pearl fishing has been carried on in modern times are France, Germany, Austria, Scandinavia, Denmark and Russia.

In the east of France the pearl fisheries of the Vologne, in the department of the Vosges, are of special interest and have been celebrated for centuries, while in the western part of the country the pearl mussels have been exploited in the Adour, the Charente, the Gironde and tributaries, the Garonne and the Dordogne and their affluents, and many other streams. In Germany the pearl fisheries are most important in the streams of the southern districts, in Bavaria, Saxony and Silesia. In Austria the fisheries have been prosecuted in the province of Bohemia from very early times. The fisheries of the Wottawa River were noted in 1560 and this river has long been known as the "the gold- and pearl-bearing brook." Formerly along its shores, gold washing was more or less carried on, as well as the fresh-water pearl-mussel industry. In Hungary the native pearls have been popular with the Magyar women from early times, and very many yet

exist in old Hungarian jewelry. In Denmark no pearl fisheries now exist; but three centuries ago the gems were obtained in the Kolding Fjord, in Jutland. In Norway most of the rivers and streams, especially on the west and south-west coast, have been noted for pearls from the 17th century; while in Sweden, pearl fisheries were noted, in 1562, by Olaus Magnus, Archbishop of Upsala. In Russia the pearl mussel is found in many streams; it occurs throughout Archangel, in most of the rivers flowing into the White Sea, Lake Onega, and the Baltic Sea; it likewise occurs in the Volga Watershed. In the government of Archangel pearls have been collected for centuries from the streams flowing into the White Sea and Arctic Ocean. Middendorff gives us a detailed account of the Lapland pearl fisheries and relates that they have been carried on exclusively by the shore Laplanders; but owing to the small returns, they have been neglected in recent times. The pearls obtained are somewhat dull in colour, which in the opinion of the fishermen is caused by the mysterious influence of the copper money which they carry with them. The Tuloma was formerly a productive river; its pearls were sold in Kola, and were sent from there to Archangel to be pierced. The Tjura also yielded many pearls; but since a Laplander was drowned while fishing for them, the idea has spread that the spirit of the river guards the pearls, and the natives hesitate about seeking them. In the grand duchy of Finland, in the province of Olonetz, and in the Baltic Provinces, pearls have been sought after for three centuries or more. The areas where pearl fishing is conducted in other parts of Russia—the Volga Watershed. the Don, the Dnieper, etc.—are indicated on the accompanying map.[44]

[44] The above information is mostly extracted from Von Hessling "Die Perlmuscheln und ihre Perlen," Leipzig, 1859; also Kunz and Stevenson, *op. cit.*

In India pearls were known and appreciated many centuries before Christ. They are frequently mentioned in Indian mythology, their discovery being attributed to Krishna, the eighth avatar or incarnation of Vishnu, who is said to have searched the ocean for these gems and then carried them to India as a wedding gift to his daughter Pandaïa. The Atharvaveda (at least 500 years B.C.), alludes to an amulet made of pearls and pearl-shell used for bestowing long life and prosperity upon young Brahmanical disciples.[45] The two great epics of ancient India, the Ramayana and the Mahabharata, also refer to pearls, and the former speaks of a necklace of twenty-seven of these gems, and refers to pearl drillers to accompanying a great military expedition. Ancient Indian deities are represented as being adorned with these gems, and, according to Varahamihira, the Indian astronomer, the statue of the Sun-god, Mithra, wore a crown upon his head, and was decked with chain-work of pearls, and earrings also of pearl. Pearls and diamonds served as eyes for images of the gods ; they were also employed to decorate the interior of Buddha's tomb, and shone upon the beautiful box containing his sacred tooth. Distinguished Indian women wore purple draperies ornamented with pearls, and on great public occasions their arms were covered with them ; and they even wove them into their hair.[46] Special esteem seems to have been accorded to rose coloured pearls, for red pearls (*Lohitamukti*) form one of the seven precious objects which it was incumbent to use in the adornment of Buddhistic reliquaries, and to distribute at the building of a Dagopa.[47]

[45] See translation by Maurice Bloomfield in "Hymns of the Atharvaveda," Oxford, 1897, p. 62.

[46] Von Hessling, *op. cit.*, pp. 1-2 ; Streeter, *op. cit.*, pp. 24-25 ; Kunz and Stevenson, *op. cit.*, pp. 3-4.

[47] Lovell, *op. cit.*, p. 97 ; see also Yule's "Marco Polo," ii., p. 203.

Notwithstanding their great fame, the pearl fisheries of India are of small extent. The only resources are the pearl reefs situated on the Madras coast in the vicinity of Tuticorin, on the northern shore of the Gulf of Manaar; reefs of local importance at Kananur on the Malabar coast and on the Ratnagiri coast below Bombay; and the more important reefs off the coast of Nawanagar, on the south side of the Gulf of Cutch. The fisheries of the Madras coast were well known in the time of Ptolemy, and pearls from this source are alluded to by several early writers.[48]

According to Hornell,[49] the ancient Tamil classics furnish evidence of the existence of important pearl fisheries, together with those of chank shells, on the Indian shore of the Gulf of Manaar. One reference contained in the "Maduraikkanchi," a Tamil poem, "incidently describes the ancient city of Korkai, once the sub-capital of the Pandyan Kingdom and the great emporium familiar to Greek and Egyptian sailors and traders and described by the geographers of the 1st and 2nd centuries A.D. under the name of Kolkhoi."

"In one passage," Hornell informs us, "the Parawas are described as men who dived for pearl oysters and for chank shells and knew charms to keep sharks away from that part of the sea where diving was being carried on. Another passage depicts the city of Korkai, then a seaport at the mouth of the Tambraparni, as the chief town of the Parawas and the seat of the pearl fishery, with a population consisting chiefly of pearl-divers and chank-cutters."

It is of some interest to note that the Parawas to-day continue as from time immemorial to provide the con-

[48] Kunz and Stevenson, *op. cit.*, pp. 128-9.

[49] James Hornell, "The Sacred Chank of India," Madras, 1914, pp. 42-3 (*Madras Fisheries Bulletin*, No. 7).

tingent of divers employed for the pearl and chank fisheries of the gulf of Manaar.

In the first century A.D. Argalus, in the neighbourhood of Korkai, appears to have been a station where the Gulf of Manaar pearls were perforated. Here also were to be purchased fine muslins sprinkled with pearls.[50]

According to Kunz and Stevenson (*op. cit.*, p. 131), two other species of pearl-producing mollusks are collected in the Madras Presidency. One of these is a species of mussel, bright green in colour, known as *Mytilus smaragdinus*, collected from the estuary of the Sonnapore River, near Berhampore. Small pearls of inferior quality are found therein, and are sold chiefly for chunám[51] and for placing in the mouths of deceased Hindus. The other species is the *Placuna placenta*—the so-called "window-glass" shell—which is abundant from Karachi, near the Baluchistan border, to the Kanara district south of Bombay. It is found also in Pulicat Lake, and in the vicinity of Tuticorin. Where it occurs in any abundance it is collected for the sake of the small pearls found therein. These pearls are highly valued by the Hindus, in calcined or powdered form, for medicinal purposes, and especially for mixing with the betelnut; they are also in considerable demand for placing in the mouths of deceased Hindus of the middle class, instead of the sea pearls which are used by the wealthy, or the rice employed in a similar manner by persons of poorer rank. The practice of placing pearls in the mouth of the dead is an old one in India and was noted by Marco Polo more than 600 years ago.[52] As we shall see later on in this paper,

[50] Vincent, "The Commerce and Navigation of the Ancients in the Indian Ocean," London, 1807, vol. ii., p. 519.

[51] Chunám: lime prepared from burnt shells, etc., used for building purposes, and by natives for mixing with betel for chewing.

[52] Kunz and Stevenson, *op. cit.*, p. 310.

it is also a very ancient custom in China, and, more interesting still, in the New World, where it appears to have been carried by the great wave of megalithic culture embodying so many curious and remarkable elements. In no other way can it be accounted for here, as it is inconceivable that such an arbitrary practice could have developed independently in Asia and in America.

India is the home of many strange ideas concerning the origin of pearls. From very early times they have been considered as consolidated dew-drops, which Buddha in certain months showered upon the earth, when they were caught up by the gaping oysters whilst floating on the waters to breathe.[53] Streeter[54] quotes many other equally curious superstitions regarding their origin, from a work by a native Indian Prince, the Rajah Sourindro Mohun Tagore. In his 'Mani-Málá or a treatise on Gems,'[55] this writer, in addition to the dew-drop theory, refers to the general belief that pearls originate in clouds, elephants, boars, conch-shells, fish, serpents, and bamboos. The cloud-begotten idea seems to be a variant of the dew-drop origin. "Pearls that originate in the head of the Elephants of Khambogia are large as the fruit of the *emblic Myrobalan*, heavy, and more yellow, but not more lustrous than the other kinds." "Pearls which originate in the head of the Boar are generally white, like the tusks of that animal." "A pearl derived from the conch-shell is of large dimensions, has the same colour as the inner surface of that shell-fish, and is productive of good fortune to its possessor."[56] "Pearls attained from the mouth of sea-fish are singularly round, small and light. Those which

[53] Lovell, *op. cit.*, p 47.

[54] Streeter, *op. cit.*, pp. 57-62.

[55] 2 vols., Calcutta, 1881.

[56] Pearls are well-known from *Strombus*, *Turbinella*, and other conch-shells.

originate in whales are agreeably round, but not highly lustrous.[57] "Pearls which originate in the crest of Serpents, are beautifully round . . . . the serpents who bear them are the descendants of Vásuki, sovereign of the snakes, are not born everywhere, and are rarely seen by men in some sacred ground.[58] "Pearls which originate in the Bamboo are clear as the moon, and are like the Kakkol fruit in shape."

The same Indian authority referred to above says, "In certain places pearls are found on the head of frogs; learned men class them with serpent-pearls." This prominent Indian belief which makes the head of the frog or toad Nature's laboratory for the manufacture of pearls, was at one time widely prevalent in the British Isles.

This idea is immortalized in the familiar lines of Shakespeare—

> "Sweet are the uses of adversity,
> Which, like the toad, ugly and venemous,
> Wears yet a precious jewel in his head."

On the Indian idea of the supposed medicinal properties of pearls the Rajah Sourindro Mohun Tagore has much to say in the work already quoted. The burnt powder of these gems, if taken with water, cures hemorrhages, prevents evil spirits working mischief in men's minds, cures lunacy and all mental diseases, jaundice, etc., etc. Used as a dentifrice it strengthens the gums and cleans the teeth. Rubbed over the body with other medicines it cures leprosy and all skin diseases. And so on.

In addition to the pearls themselves, the burnt pearl-shells are also looked upon as efficacious in the cure of many ailments; but chank-shell powder appears to sur-

[57] Pliny, "N. H.," bk. ix., ch. 24, mentions fish which have a "stone" in the head. He refers doubtless to the ear-bones or otoliths.

[58] Is this a confusion of the pearly-like granules and shields found in slugs, the 'snail-stones' credited with the property of strengthening eyes, etc.?

pass either of these substances, the special significance and auspicious nature of the chank inspiring the confidence of patients in the value of this medicine.[59]

The superstitious reverence paid to these white shells by the Hindus and other oriental people, recalls the reverence paid by the Greeks and Romans to snails and other shells. The internal pearly-like shell of some of the slugs was believed by them to be highly efficacious in the cure of fevers, diseases of the head or headaches. The granular substance representing the shell in some species was also believed to facilitate teething if suspended from the necks of infants.[60] In the same category are to be included the worn fragments of shells, or "snail-stones," which were formerly much commended in Guernsey and the Highlands of Scotland as a remedy for diseases of the eyes.[61] According to Humboldt,[62] similar worn fragments of shell, known as "eye-stones" (*piedras de los ojos*), were regarded by the inhabitants of Araya, Venezuela, S. America, as possessing extraordinary powers in the expulsion of foreign particles accidentally introduced into the eye. Kunz[63] also records that "eye-stones or opthalme are taken from the crawfish in the Sandwich Islands. They have been used from time immemorial for removing dust or other particles from the eye." These "eye-stones" are probably the so-called "crab-stones" or "crab's-eyes," the concretions of carbonate of lime, developed on either side of the stomach in the lobsters, crayfish, etc., before the time of moulting.

[59] See Hornell's interesting work on "The Sacred Chank of India," *Madras Fisheries Bulletin*, No. 7, 1914, especially Chap. iii.

[60] Pliny, "N. H." bk. xxix., ch. 36.

[61] Johnston, "An Introduction to Conchology," London, 1850, p. 78.

[62] Humboldt, "Pers. Narrative," i., p. 197 (Bohn's Ed.).

[63] G. F. Kunz, "Folk-lore of Precious Stones," *Memoirs Internat. Congr. Anthrop.*, Chicago, 1894, p. 273.

In European countries these concretions were formerly used in the preparation of certain medicines.[64]

Like the pearl fisheries of southern India, those situated off the north-west coast of Ceylon, in the Gulf of Manaar, directly south of Adams Bridge, are of very great antiquity. They are said to have been well-known to the Phœnicians who traded here in purple robes and other commodities.[65] Pliny[66] refers to Taprobane (Ceylon) as the most productive of pearls of all parts of the world. Ptolemy, Strabo, and other ancient writers also speak of their importance. According to the "Mahavansa," pearls figure among the native products sent as presents from King Vigaya of Ceylon to his Indian father-in-law, in about 550 B.C.; and again when in 306 B.C., King Devanampiyabissa sent an embassy to India the presents are said to have included eight kinds of Ceylon pearls.[67] According to Tennent[68] the eight kinds of pearls were: "haya (the horse); gaja (the elephant); ratha (the chariot wheel); maalaka (the nelli fruit); valaya (the bracelet); anguliwelahka (the ring); kakuda-phala (the kabook fruit); and pakatika, the ordinary description."

The only other locality in Ceylon where pearls are obtained is Tamblegam Lake, on the north-eastern coast, near Trincomali. Here *Placuna* fishing is carried on for the sake of the diminutive pearls contained in them. These are exported to the coast of India, to be burned

[64] Jeffreys, "Brit. Conch." i. 1862, p. lxv.

[65] Streeter, *op. cit.*, p. 186; Tennent, "Ceylon," London, 1859, 2nd ed., vol. i., p. 551.

[66] Pliny, "N.H.," bk. ix., ch. 54.

[67] W. A. Herdman, "Report on the pearl oyster fisheries of Ceylon," Royal Society, London, pt. i., 1903; also Kunz and Stevenson, *op. cit.*, p. 4.

[68] Tennent, *op. cit.*, i., p. 446.

into lime for mixing with betel for chewing. (Tennent, *op. cit.*, ii., pp. 491-2.)

We have little definite information regarding the early use of the fresh-water pearls of India except the statement in the "Periplus"[69] that a considerable traffic, consisting of pearls, betel, Gangetic spikenard, and Gangetic muslins, passed through the market town of Ganges, situated on the river of the same name. Schoff, in his annotations of this work says "these (pearls) were not of best quality; as Dr. Taylor remarks, those of the Ganges streams are inferior, being small, often irregular, and usually reddish."

Eastward of India a most interesting pearl fishery exists in the Mergui Archipelago (Lower Burma.) According to Kunz and Stevenson (*op. cit.*, p. 134), this fishery originated with the Selangs or Salangs, a nomadic race of maritime gipsies, supposed to be of Malay descent. Their early history is unknown, and no information exists as to when these people first found profit in searching for pearls. It was probably many centuries ago, and for a long time they made contributions of them to the Buddhist rulers of Burma.

In the Malay Archipelago pearl-oysters are among the important resources of the surrounding seas of Sumatra, Java, Borneo, Celebes, the Aru Islands, the Moluccas and New Guinea. For hundreds of years pearl-shell and pearls have been gathered by the natives from these waters, and especially on the coast of the Aru Islands, Halmahera, and adjacent Islands, on the east coast of Celebes, and about the Sunda group. Pearl-oysters also occur about many other islands in this

[69] "The Periplus of the Erythrean Sea: Travel and Trade in the Indian Ocean by a merchant of the First Century." Translated from the Greek and annotated by Wilfrid H. Schoff. London, 1912.

neighbourhood, including the Sulu Archipelago and the Philippines.[70]

Throughout Malaysia, including the Philippines and Sulu Islands, the pearl is known as *mutya*, *mootara*, *mutyara*, or some similar name, closely resembling the Sanskrit *mukta*, or the Cingalese *mootoo*, indicating the source of the influence originating the fishery and trade of this region.[71]

At Pados Bay, island of Borneo, *Placuna* fishing is also carried on, and the shells, dried meat, and the seed-pearls they contain, all form important articles of commerce. The seed-pearls are used as a form of currency between the fishermen and the Chinese traders.[72]

Throughout the Malay Archipelago, and especially on the coast of Borneo, the natives allege that "breeding pearls" exist, that is to say, there are pearls which possess the power of reproduction or rather germination. It is the generally accepted belief that if a few pearls of good size are sealed up in a box together with some grains of rice and a little cotton wool, they will increase in number as well as in size. It is asserted that on opening the box after several months, one or more small pearls will be found therein, and the original ones none the worse; but the grains of rice will have the appearance of having their ends nibbled as if by rodents.[73]

In China pearls appear to have been held in great esteem since before the Christian era. They are repeatedly mentioned in the ancient literature of that country, but, owing to the traditional nature of some of

[70] Von Hessling, *op. cit.*, pp. 71-4; Kunz and Stevenson, *op. cit.*, pp. 212 seq.

[71] *Ibid.*

[72] Kunz and Stevenson, *op. cit.*, p. 221.

[73] Streeter, *op. cit.*, p. 69; Kunz and Stevenson, *op. cit.*, p. 296.

these works, it is impossible to fix, with any degree of accuracy, the period when they were first appreciated. Some translators of Chinese books give a date as early as the 23rd century B.C., but other authorities are inclined to take a more moderate view.

One of these early Chinese works, the "Shan Hai King," presents us with some extraordinary information regarding the existence and origin of pearls. According to Streeter,[74] "the 4th book of this work, or 'The Classic of Mountains and Rivers,' refers to the Li river, one of the affluents of the Tung-Ting Lake, which drains the north-west portion of Hunan. 'In it are many Chu-pick fish' (or water animals). 'These look like lungs, but have eyes and six feet, and they have *pearls*. They taste sour but pleasant, and are not unwholesome.' . . . The same work also states that wild animals were found which looked like sucking-pigs, but have *pearls*." The identity of the curious Chu-pick fish is not clear. Streeter says their existence is confirmed in Lüshi's edition of the "Book of Confucius," and remarks: "they are probably cuttle-fish with six tentacles." Cuttle-fish, however, are essentially marine animals, and, moreover, possess at least eight arms, or tentacles. As mentioned previously (p. 23), concretions of carbonate of lime, resembling pearls, are found in some forms of freshwater crustaceans, such as the crayfish, but here again, though eyes are present, these animals have eight legs. It is not unlikely that the pearl-bearing animals in question were freshwater mussels, the addition of the eyes and feet being due to some confusion in the translation of the passage.

In the oldest Chinese dictionary, the "Bh'-ya," pearls are mentioned as precious products of Shensi in the western part of the Empire. As Shensi is an inland

[74] Streeter, *op. cit.*, p. 63.

province in the very heart of China, these again must have been freshwater pearls.[75]

In the "Tribute of Yü" (Shoo King, pt. iii. bk. i.),[76] we find it stated that Yü received as tribute, "oyster-pearls and fish" and "baskets full of deep azure silks," from the wild tribes about the river Hwae (or Hwai), between the Ho and Keang rivers [Kiangsu, E. China]; and from the district of King-chow he received "strings of pearls that were not quite round," together with "baskets filled with deep azure and purple silken fabrics."[77]

Though seemingly acquainted with the local freshwater pearls at a very early period, it would appear that the marine pearl was unknown to the Chinese until about 400 B.C., when commercial intercourse between China and the west had become fully established.

According to Lacouperie,[78] to whom we are indebted for much valuable information concerning the pearl-trade in China, traders from the Indian Ocean (Erythrean Sea) arrived in the Gulf of Kiao-tchou (South Shantung) in the 7th century B.C. They established two colonies at this place and entered into trade relations with cities in Shantung, Shansi, Shensi, Kiangsu, Honan, and other states. Though pearls are not mentioned among the objects they introduced at this period, it is not a little curious to find that their sphere of influence coincides in a remarkable manner with the area where pearls are said to have been first known in China. This fact is significant

[75] *Ibid.*, pp. 27 and 253.

[76] See translation by Dr. James Legge, in "The Chinese Classics," 1865, vol. iii., pt. i., pp. 107 and 116.

[77] We have no means of ascertaining the source of the purple colour of the silks used as tribute, but the point is of interest in connection with the celebrated purple of the ancient Tyrians. Is it possible that this famous dye had been introduced already into China?

[78] Lacouperie, *op. cit.*,

and would seem to suggest that it was through the influence of these traders that the Chinese commenced to fish for the pearls contained in the mussels of the local rivers.

About the 5th century B.C., Erythrean merchantmen began to use Hang-tchou Bay as a calling station, in addition to their earlier and more northern ports in the Gulf of Kiao-tchou, bringing with them large pearls from the Persian Gulf, and mother-of-pearl from the Indian Ocean. This latter commodity is stated to have been used to adorn the tomb of Duke Yü of Tsin, who died in 419 B C. That the real pearl was a novelty at this period is gathered from the expressions used by writers of the 4th century Meh-ti, Lieh-tze, Tsou-hien, and others. In some cases it is associated with the Ye-Kwang—the stone which shines at night, otherwise yakut ruby of Bardakshan. "And the name of Ming-gwet, a transfer and folk-etymology of the western word for it, shows moreover its western origin, most probably from the pearl fisheries of the Persian Gulf, not of Ceylon."[79]

From this time onwards pearls were among the staple articles imported into China by these same traders, though the latter had several times to change their stations and retreat southward owing to civil wars and the advance in power of the Chinese. They used Kwei-ki, near the present Ning-po, as their emporium until the Han Empire extended its sway there in 201 B.C., when they made Tung-yeh (present Fuhtchow of Fu-kiang) their station for a time, importing big pearls from the Persian Gulf. These were transhipped from there to Kwei-ki, which was a market for them. In 187—140 B.C., one Tchu-tchung was

[79] Lacouperie, *op. cit.*, pp. 180-1 and 365; *Ming-gwet*, mod. *Ming-yueh*, shining moon.—Cf. Sanskrit, *marakata*; Greek, *maragdos*; Latin, *margarita*; Persian *marvid*; etc. (fide Lacouperie).

trading in pearls at Kwei-ki, some of the gems being of remarkably large size.

The rising of the Nan-Yueh kingdom attracted the foreign trade to the region of the present Canton, and on the conquest by the Nan-Yueh emperor of the country westward, in 179 B.C., the Hormuzian or Hwang-tchi (yellow-fingered) sea-traders,[80] as they were called, established themselves in the Island of Hainan, where they discovered pearls on the west coast and created the pearl fisheries of Tchu-yai, *i.e.* the coast of pearls (present Yai tchou). They traded with the Nan-Yueh through a station called Hop-pu, near the present Pakhoi, their goods reaching the principal market of Hêng shan, east of Nan-ning, in S.W. Kwangsi, on the Yü Kiang leading by the Pearl river to Canton.

In 110 B.C. these Hormuzian sea-traders once more removed their chief landing place, establishing it further south, on the west of Cape Cambodia, on the east side of the Gulf of Siam, in Tcham, the Zabai of Ptolemy. From here they traded Persian Gulf pearls to Kattigara and Hoppu (near the present Pakhoi).

In the early Christian era, Cingalese traders seem to have taken over most of the trade with China. Among the articles of commerce mentioned in the Annals of the Eastern Han dynasty, in 69 A.D., are bright pearls and oyster-pearls from Ceylon.[81]

It is of some interest to note here that pearls are obtained at the present day in the Gulf of Siam from a small oyster with a thin shell. Kunz and Stevenson (*op.*

[80] Names derived from Hormuzia, near the Persian Gulf, and from the use of henna to dye their fingers.

[81] Lacouperie, *op. cit.*, p. 252, and p. 255 note 1112; *Kwang-tchu*, i.e. bright pearls, different in name from the *Ming-gwet* pearls of the Persian Gulf; *pang-tchu*, oyster-pearls (? pearl-oyster shells).

cit., p. 149) inform us that "the Siamese do not especially value pearls, attributing superstitious sentiments or ill luck to them." They further remark: "Some fine old specimens of marquetry in which these [pearl] shells were used exists in the Buddhist temples at Bangkok. This art of inlaying is almost lost to-day among the Siamese, and there is said to be only one man in the king's palace who can lay any claims to proficiency in working mother-of-pearl shell."

In China during the Han dynasty, De Groot informs us,[82] "pearls also occupied a place among the objects which were introduced into the mouth of the dead. At least it is stated in the funeral ritual for the Sovereigns of this house that 'their mouths were filled with rice, and pearls and jade stone were put therein, in accordance with the established ceremonial usages.' And the 'Poh hu thung i,' a well-known work professedly written in the first century, says: 'On stuffing the mouth of the Son of Heaven with rice, they put jade therein; in the case of a feudal lord they introduce pearls, in that of a Great officer and so downwards, as also in that of ordinary officials, cowries are used to this end.'"

The free use of pearls and other precious objects in connection with the ritual of the dead, seems to be founded on a desire to procure light for the soul, that it may be conducted safely along its paths in the dark beyond. But the chief object of this practice, it would appear, is to save the body from a speedy decay.[83]

The custom of placing articles of value in the mouth of the dead is analogous to similar practices widely prevalent in other parts of the world. It is well known to

[82] De Groot, "The Religious System of China," Leyden, 1892, vol. i., p. 277.

[83] *Ibid.*, p. 278.

have obtained among the Greeks, the Romans, the Hindus and the ancient Mexican emperors.[84]

Reference has already been made (*supra* p. 20) to the placing of pearls in the mouths of deceased Hindus; a similar custom was practised by the "mound builders" of the Mississippi valley (see p. 45).

Pearls are frequently alluded to in Chinese literature as the depositories of Yang matter, and as such ranked among the bearers of vitality. Medical works declare that they can ensure and facilitate the procreation of children, and these same books say that pills made of pearls mixed with the blood from the comb of a cock and inserted in the eyes of a person who has suddenly expired, or lost his speech, can be useful in recalling the person to life.[85]

The valves of *Unio tientsinensis*, the Ko-fen of the Chinese, are used by these people as a powder in medicine, and occasionally as one of the ingredients of pills, as a substitute for the pearls from the marine pearl-oyster. On account of the costliness of pearls from the latter source, pills and powders made from them are said to possess marvellous powers of cure, and are even used in the treatment of small pox.[86]

It would seem that in China, and in other oriental countries, a distinction is made in the therapeutic properties of so-called "virgin" pearls and of those pierced or bored for stringing. One Chinese natural history states that bored pearls will not serve for medicine, for which unpierced ones should be used.[87]

Legends of "lightning pearls," "pearls shining during

[84] *Ibid.*, p. 279, footnote.

[85] *Ibid.*, pp. 217 and 277.

[86] Lovell, *op. cit.*, pp. 75 and 102, quoting J. O. Desbeaux, "Essai sur la Pharmacie et la Matière Médicale des Chinois."

[87] Kunz and Stevenson, *op. cit.*, pp. 308-9.

the night," "pearls lighting like the moon," *inter alia*, are current in considerable numbers in the native literature. Allusions are made to pearls so brilliant that they were visible at a distance of nearly a thousand yards. Rice, it is alleged, could be cooked by the light from them. One found about the beginning of the Christian era, near Yangchow-fu, province of Kiang-su, was reported so lustrous as to be visible in the dark for a distance of three miles.[88]

The "Ch'êng Yü K'ao," compiled by Ch'iu Chin, *alias* Wên Chuang, a famous scholar of the Ming dynasty (born A.D. 1419; died 1495),[89] contains several interesting references to pearls, some of the most curious being that "pearls can ward off the calamity of fire"; "the mermaid wept tears that became pearls"; "Ma Ku threw grains of rice which became pearls"; and: "He who cut open his stomach to hide the pearl loved mammon more than his life." T'ai Tsung of the T'ang dynasty (A.D. 627—650), when warning his minister against covetousness, and licentiousness, said that those who were guilty of these offences were as worthy of ridicule as the merchant from Syria, who opened his stomach to hide the pearl. One Chinese work states that when the whale dies, its eyes are changed into pearls.[90]

Regarding the origin of pearls many fantastic theories are to be found in ancient Chinese literature. By some writers they are credited as originating in the brain of the fabled dragon, and frequent allusions are made to pearls under the throats and in the mouths of these creatures. In China and Japan, as well as in India, pearls were considered to be in the special possession of dragon-

[88] De Groot, *op. cit.*, p. 277; Kunz and Stevenson, *op. cit*, p. 5.

[89] See translation by J. H. Stewart Lockhart in "A Manual of Chinese Quotations," Hong Kong, 2nd Ed., 1903.

[90] *Ibid.*, pp. 395 and 402.

shaped sea-gods, or Nagas.[91] These mythological creatures —gods of water, thunder, rain, and wind—were believed to have their abode in certain ponds and rivers, and especially in splendid palaces at the bottom of the sea. Hence we find many curious stories in the literature of these countries. In Oldham's work "The Sun and the Serpent" (London, 1905, p. 61), allusion is made to the Nagas of southern India living under the sea in a place called the land of gems.[92] Legge, in the "Sacred Books of the East" (vol. xl., p. 211), quotes a legend from Shuangtze, a writer of the 4th century B.C., who says: "Near the Ho river there was a poor man, who supported his family by weaving rushes. His son, when diving in a deep pool, found a pearl worth a thousand ounces of silver. The father said: 'Bring a stone and beat it to pieces, a pearl of this value must have been in a pool nine khung deep and under the chin of the black dragon. That you were able to get it must have been owing to your having found him asleep. Let him awake, and the consequences will not be small.'"[93] Another old Chinese account of the Lien-chan district, in the Canton province (Kwantung), states: "In the sea there is an island with a lake, into which the barbarous natives dive for shells; some years they are abundant, and in others scarce. There is a myth amongst the fishermen of a walled city at the bottom, guarded by monsters, containing pearls of large size and splendour, but which cannot be obtained for the guards; small ones, growing outside the city walls like grass, being the only ones obtainable."[94]

[91] On the subject of the Chinese dragon, see Dr. M. W. de Visser, "The Dragon in China and Japan," Amsterdam, 1913.

[92] W. J. Perry, *op. cit.*, p. 11, quoting Oldham.

[93] Kunz and Stevenson, *op. cit.*, p. 302, quoting Legge.

[94] F. Hague, "On the Natural and Artificial production of Pearls in China," *Journ. Roy. Asiat. Soc G. B. & I.*, vol. xvi., pt. 2, Art. xv, p. 281.

All these myths seem to be but modifications of the old idea of social relations between pearl-oysters and sharks, or of the curious story quoted by Pliny (Bk. ix., ch. 55) from Megasthenes that pearl-oysters lived in communities, just like swarms of bees, each of them being governed by one remarkable for its size and great age (or splendour), and which at the same time possessed marvellous skill in keeping its subjects out of danger; the divers, it is said, took especial care to find these, so that the others might easily be taken.

The art of artificial pearl-making seems to have been practised by the Chinese for several centuries. Mr. F. Hague, British Consul at Ningpo, informs us that "there is a note that at the commencement of the seventh century, pearls were made of a composition or medicine. The art may have been lost, or it may be the same as that now employed at, and which originated at, Canton."[95] In conjunction with Dr. Mc Gowan, an American physician resident at Ningpo, the method pursued by the Chinese with the "Mussel-pearl" was carefully investigated, and excellent accounts of this interesting industry have been published.[96] The practice of the art is carried on in two villages near the city of Teht-sing (Titsin) in the northern part of Chihkiang (Chekiang), in a silk-producing region. In May or June, quantities of large freshwater mussels (*Dipsas plicatus*) are brought from the Tāhū, a lake in Kiang-su, some thirty miles distant, and after a few days' respite in bamboo cages in water, various matrices are introduced between the animal and the shell by means of a bifurcated bamboo stick. After a sufficient number has been treated they are placed in canals, pools, and streams. In about a year the matrices become incrusted

[95] *Ibid.*, p. 282.

[96] *Ibid.*, pp. 280-4; and McGowan, *Journ. of Soc. of Arts*, ii., pp. 72-5.

with the pearly nacre, and the mussels are taken out of the water, and the "pearls" detached by a sharp knife. The matrices used vary in form and substance, the most common being pellets of mud. Another class consists of small images, especially of Buddha, in the usual sitting position, or sometimes of a fish; they are made of lead, cast very thin. The invention of the art is attributed to a native of the place, named Ye-jin-yang, to whom a temple has been erected, in which divine honours are paid to his image. He is said to have lived about A.D. 1200—1300. The topography of Chihkiang mentions a pearl sent to Court in 490 A.D., which resembled Buddha, being three inches in size. The resemblace, however, may have been fanciful; the "pearls" now made are but half-an-inch long.

Other writers have given similar accounts of this curicus industry, but the most remarkable is that related by Mary Roberts in her little book on the "Popular History of the Mollusca" (1851, pp. 275-6). She tells us that in the possession of Sir Joseph Banks were "several Chinese Chamæ [? *Unio*], in the shells of which were contained bits of iron wire, covered with a substance of a pearly nature. These wires had evidently once been sharp, and it seemed as if the mollusks, anxious to secure themselves against the intrusion of such unwelcome visitors, had encrusted, and thus rendered blunt, the points with which they came in contact." She concludes by remarking: "may not, therefore, the process employed in past ages be still practised? And are we not authorized in conjecturing that these bits of iron, which probably had slipped from the hands of the Chinese workmen, and remained in the animal, resembled the spikes noticed by Philostratus as being used by the ancient people who inhabited the banks of the Red Sea, for the purpose of

pricking mussels?" In view of the fact that the Chinese retain, with few alterations, the arts and customs of their ancestors, these suggestions are not at all improbable. In this connection it will be of interest to notice the particular skill possessed by the Chinese in drilling holes in pearls. This, as pointed out by Lacouperie (*op. cit.*, p. 241, note 1037), they may have learned from the pearl-traders of Hormuz who were celebrated for their ability in this respect, and to whom Ceylon pearls were sent for that purpose.

At what period pearls were first appreciated in Japan is not known. The occurrence of pearls on the coasts of that country is repeatedly alluded to in ancient works relating to Japan. According to Kunz and Stevenson,[97] they are mentioned in the Nihonki, of the eighth century, the oldest Japanese history. Dr. T. Nishikawa also states they were used in Japan for ornamental purposes more than a thousand years ago. Large pearls derived from the abalone, or *Haliotis*, are found in images of Buddha made in 300 A.D. Freshwater pearls, from *Dipsas* and *Unio*, appear to have been also used.[98] In Marco Polo's time these people still carried on the Chinese custom of placing pearls in the mouth of the dead. We learn from this famous traveller that "in the island of Chipan-gu (the kingdom of Japan), the Chinese Jih-păn-Kwē, rose-coloured pearls were abundant, and quite as valuable as the white ones," that "some of the dead were buried and others were burnt," and "when a body was burnt they put one of the rose-coloured pearls in the mouth, for such is their custom."[99] These coloured pearls were doubtless derived from conch-shells.

[97] Kunz and Stevenson, *op. cit.*, p. 147.

[98] *Ibid.*, p. 414.

[99] Colonel Henry Yule, C.B., "The Book of Ser Marco Polo" (Book iii., ch. ii.), vol. ii., p. 200.

In 1727, Kaempfer noted that pearls were obtained by the Japanese from small sorts of oysters, called *akoja*, not unlike the Persian pearl-oyster; also from the yellow snail shell and from the *taira gai* (*Placuna*), and especially from the awabi or abalone (*Haliotis*).[100]

From narratives of China by the Jesuits, there appears to be some evidence of a former pearl fishery in the neighbourhood of Saghalin Island, but the intelligent navigator, M. de la Perouse, expressed much doubt on this point. He acknowledged that his people found oysters that contained pearls, and admitted it possible that a few families of fishermen may have united together for the purpose of fishing for pearls, in order to exchange them for nankeens and other articles of commerce from China; but he did not observe that any of the natives of the places at which he touched on the coast estimated this kind of pearl more than common beads.[101] There seems to be, however, ample evidence of old-established pearl-fisheries in this region, judging from the various records summarized by Von Hessling in 1859 (*op. cit.*, pp. 201-4). In Manchuria, he tells us, pearls have been fished, from the oldest time to the present day, in the streams which flow into the Songari, a tributary of the Amur. Witsen, writing in 1705, mentions the pearls from the Gan, a tributary of the Amur, and also from the islands of the Amur at the junction of the Skilka and Argun. Pearl-fisheries were established here by the Russians nearly two centuries ago. Pearls are finer and more plentiful, says Hessling, in southern Manchuria, especially in Lake Heikow or Hing-tchou-men, "Black Lake" or "Gate of Precious Gems," where they have been fished for ages for the account of the Emperor of China.

[100] Kunz and Stevenson, *op. cit.*, pp. 147-8.

[101] G. A. Cooke, "System of Universal Geography," vol. i. (1801), p. 574.

Cooke, in 1801 (*op. cit.*, vol. i., p. 425), also speaks of the Manchurian pearls as an article of commerce, together with a plant called ginseng.[102]

In Kamtchatka, pearl fisheries are recorded from the south end of the peninsula (Lopatka), and from Nijni Kamtchatsk, on the east coast: these are possibly fresh-water fisheries. Pearls have also been found at the Kurile Islands, and at Lebäshja, on the south coast of the Sea of Okhotsk, but these were probably from sea shells, *Mytilus edulis* or *Machaera costata*, as no Unios are recorded from these places.[103]

An interesting reference to very early intercourse between north-eastern Asia and China is quoted by Lacouperie in his work already cited (p. 353, note 195). It appears that the "Shih y hi" (kiv. 5) mentions a mission of a Nêlê country in 193 B.C., from beyond Fusang (Saghalin). Dr. G. Schlegel identifies this with the country of the Tchuktchis, in which Lacouperie concurs. No information is given as to the object of the mission, but it seems probable that it was for the purposes of trade. If so, it is not unlikely that the envoys would learn of the appreciation of the pearl by the Chinese—who were well acquainted with the gem by this date—and benefiting by the knowledge, they might have instituted pearl fisheries on their own account. The present

[102] Ginseng (*Panax schinseng*) is a native of Tartary and Northern China, growing at one time abundantly in Manchuria, but its great use in China has caused it to become scarce. It is a low herbaceous plant with forked roots, which the Chinese imagine resembles the human form, and is supposed to ward off all diseases. It is slightly bitter and aromatic, but is not of much repute with European doctors. *Panax quinquefolia*, a native of North America, is sometimes substituted for it (Smith, "Domestic Botany," 1871, p. 362). Ginseng is used by the Indians of Canada, Virginia, South Carolina, etc., along with Snake root. (Cooke, *op. cit.*, ii., pp. 32, 69 and 79).

[103] Von Hessling, *op. cit.*, p. 204.

pearl fisheries in this region, detailed above, may be survivals of an ancient industry.

In northern Siberia, according to Witsen, pearls were found in the waters around Mangasea on the Turuchan, and a manuscript in the Moscow College notes that they were found in the river Tunguska which flows into the Yenisei. Witsen also refers to their occurrence in the rivers and streams of Irkutsk and Onon; Pallas speaks of the Ilim, a tributary of the Angara, as another river where they occur.[104]

Kunz and Stevenson (*op. cit.*, p. 410) mention an interesting discovery (made in southern Siberia in the time of Peter the Great) of a broken gold ring with a roughly-cut turquoise and two pendants, each set with two pearls separated by a garnet. This object is thought to belong to the second century before Christ.[105]

In the Pacific Islands pearls and pearl-shell seem to have been appreciated for centuries. Among the native ornaments noted by Captain Cook at Tahiti were feathers, shells and pearls; but the latter were worn chiefly by the women. In the Marquesas Islands, plates of mother-of-pearl decorated the principal head-dress of the natives, while ornaments consisting chiefly of pearl-shell were seen in Toobouai; Friendly Islands; Mangeea Island; New Caledonia; New Zealand; etc. The pearl-shell was also found to be employed in the construction of fish-hooks in many of the islands visited by early navigators.[106]

Since Cook's time a considerable literature has accumulated on the subject of these pearl-shell fish-hooks. Hedley, in his "Ethnology of Funafuti"[107] gives a most

[104] *Ibid.*, p. 201.

[105] Given as second century A.D. on plate figuring the specimen.

[106] G. A. Cooke, *op. cit.*, i. (1801), pp. 32, 36, 62, 65, 84, 85, 101, 105, 113, 131, 178, 273 and 318.

[107] *Mem. Aust. Mus.*, iii., pp. 266 et seq.

interesting account of their manufacture and distribution in the various islands of the Pacific. The pearl-shell hooks he remarks, "represented to the Ellice Islanders of past generations their most valued treasures. Apart from their intrinsic worth they acquired, as conveying a maximum of wealth in a minimum of space, an artificial value approximating to the coins of more advanced civilisations." They were appreciated to such an extent that they were frequently offered to the gods, and on Vaitupu, or Tracey Island, where the dead were buried inside the houses, they were deposited in the grave with the body, accompanied by necklaces and other ornaments. In former times messages were transmitted from atoll to atoll by means of pearl fish-hooks attached to the wings of Frigate-birds.[108]

According to Hedley the value of these hooks in the Ellice Archipelago was heightened by the rarity and inaccessibility of the shell (*Avicula cumingii*) from which they are made, the supply being principally from a bed in the Lagoon of Nukulailai. This type of hook, he informs us, is universal throughout the Pacific, being used alike by Melanesians, Polynesians, and Micronesians. Examples are recorded from Manihiki and Mortlock Islands, the Gilbert and Hawaiian Groups, Danger Island, Strong's Island, Tahiti, Tonga, Samoa, and the Solomons; also from the Carolines, the Marshalls, and the Marquesas. In New Zealand, owing to the absence of the true pearl-shell, the Maories made use of "pawa" (*Haliotis iris*) as a substitute for the flashing nacre of the *Avicula*.

Turner[109] informs us that at Nukulailai offerings consisting of pearl-shell were taken to the temple, and at

[108] Hedley, *op. cit.*, p. 266; see also pp. 47, 53 and 59; and G. Turner, "Samoa, etc.," London, 1884, pp. 282 and 284.

[109] G. Turner, *op. cit.*, pp. 280 and 288.

Nanomana similar offerings were suspended under the altars of the principal gods Foelangi and Maumau.

Among the Torres Straits Islanders pearl-shells are trimmed and worn as breast-ornaments, or carved into beautiful crescentic and other shapes to be worn as pendants either on the chest or in the ears.[110]

They also appear to have been used in mummification, as Dr. Elliot Smith has recently referred to the case of a Torres Straits mummy having the eye-sockets filled with a gum or resinous substance in which narrow oval pieces of mother-of-pearl were embedded.[111]

Crescent-shaped plates of pearl-shell are also in common use as breast ornaments in British New Guinea and the Solomon Islands, and the same shell is used as an inlay to decorate the native canoes.[112]

In the Sandwich Islands the eyes of idols were noticed by Captain Cook to be made from large pearl oysters, with a black nut fixed in the centre.

Ellis, in his "Polynesian Researches,"[113] gives us a lucid description of the curious dress worn in Tahiti at death ceremonies of chiefs. This consisted of a cap of thick native cloth fitted close to the head; in front were two large broad mother-of-pearl shells, covering the face like a mask, with one small aperture through which the wearer could look. Attached to this head-dress was a beautiful kind of network composed of small pieces of brilliant mother-of-pearl shell, each being about an inch or an inch and a half long, and less than a quarter of an

[110] A. C. Haddon, "Reports of the Cambridge Anthropological Expedition to Torres Straits," vol. iv., 1912, pp. 40-45.

[111] *Manch. Mem.* (*Lit. & Phil. Soc.*), vol. lix. (1915), No. 10, p. 93.

[112] Haddon, *op. cit.*, iv., p. 43; and H. B. Guppy, "The Solomon Islands and their Natives," London, 1887, pp. 131 and 146-7.

[113] Vol. i., pp. 412-3.

inch wide. Every piece was finely polished, and reduced to the thinness of a card. Small perforations were made at each corner to enable the pieces to be threaded together. The labour in making this, Ellis says, must have been excessive, as so many hundred pieces of pearl-shell had to be cut, ground down, polished, and perforated, without iron tools. Its manufacture was regarded as a sacred work.

Pearl-oyster shells set in whales' teeth are considered to be the most valuable ornament that a Fijian possesses; he wears it at dances hanging on his breast, and he is forbidden by the chiefs to sell it.[114]

It has been asserted by some historians that pearls were unknown in the New World in pre-Columbian times, but we have evidence that ages prior to the discovery of America by Columbus the ancient inhabitants fully appreciated these gems. Quantities of pearls, in many cases perforated for stringing as necklaces, etc., have been discovered in the mounds erected by the ancient population of the Mississippi Valley. Professor Putnam[115] records that in excavating the mounds near Madisonville, Indiana, not less than fifty thousand pearls were found, most of them pierced and injured by heat. Squier and Davis[116] found them on the hearths of five distinct groups of mounds in Ohio, and sometimes in such numbers that they could be gathered by the hundred. In addition to the pearls, quantities of other interesting objects were met with which indicate the existence of inter-tribal commerce on an extensive scale at a remote period. The

[114] H. N. Moseley, "Notes by a Naturalist on H.M.S. Challenger," 1892, p. 286.

[115] *Proc. Amer. Assoc. Adv. Sci.*, 1884.

[116] Squier and Davis, "Ancient Monuments of the Mississippi Valley," Washington, 1848.

pearls were originally thought to have been brought from fisheries in southern waters, but are now considered as having been derived, partly, if not entirely, from the fresh-water mussels (*Unio*) so abundant in the rivers of the region of the mounds. W. C. Mills, in his "Explorations of the Edwin Harness Mound,"[117] also speaks of the large quantities of freshwater pearls made into beads which were found in every section of the Harness Mound. In one instance more than two thousand of these beads were found with one burial. They are all small, some being perfectly round. Several hundred were obtained ranging in diameter from a quarter to half an inch. In some cases the large pearls had been flattened on one side and set in copper; in others, the pearls were often flattened and pierced with two holes, as if for attachment to fabrics, etc. The most curious discovery, however, in this mound was that of imitation pearls made of clay, and apparently modelled from real ones. These clay imitations appear to have been coated with mica and then burned so as to preserve a pearly appearance. This remarkable discovery is of great interest as recalling the clay pellets used by the Chinese in their artificial pearl-making industry.

At the Gartner Mound, in the same region, a shell gorget was found with a hole cut in the centre and a pearl cut and mounted to fill it.[118] And gorgets and crescents made from fresh-water pearl-shells were by no means uncommon in this and other Ohio mounds.

In his description of "The Seip Mound,"[119] situated within the largest prehistoric earthworks of the Paint

[117] *Ohio Archæol. and Hist. Quart.*, vol. xvi, no. 2, 1907.

[118] Mills, "Explorations of the Gartner Mound and Village Site," *Ohio Arch. and Hist. Quart.*, vol. xiii., no. 2, 1904.

[119] Mills, "The Seip Mound," Putnam Anniversary Volume. N.Y., 1909, pp. 110, 114 and 122.

Creek valley of Ohio, this same authority refers to other occurrences of pearls including a beautiful string of these gems in a good state of preservation from one burial; also to the discovery of bears' teeth set with pearls in what appeared to be sacred shrines for the dead.

In addition to the archæologists cited above, other noted authorities, including W. K. Moorehead, have examined the mounds of the Ohio region, and have met with abundant evidence, both in the burial and in the altar mounds, of the ancient appreciation of pearls.[120]

When found in burial mounds with skeletons, the pearls are usually at the wrists or ankles, or about the neck, or in the mouth, the latter recalling forcibly the Hindu and Chinese custom of placing pearls in the mouth of the dead (*supra* pp. 20 and 31).

In the case of the altar mounds, there is evidence of a different procedure. Instead of a burial, there was a great funeral sacrifice in honour of some distinguished person, in which numerous treasures, including quantities of pearls, were consumed, or meant to be.

It would seem that though the number of pearls encountered in the mounds of the Ohio region is very great, the graves which contain them are relatively very few. They seem to have been buried only with persons of special distinction, probably either chiefs or eminent medicine men: this preferential use of pearls, it may be observed, was also found in Asiatic countries.

In the mounds of Illinois pearls have also been met with associated with skeletons of Indians. Dr. J. F. Snyder records the discovery of large canine teeth of the bear, set with pearls, at the base of a large mound which he opened in 1895, in Brown Country, on the west side

[120] An excellent summary of the work of these authorities is given by Kunz and Stevenson (*op. cit.*, especially in Chap. xvii.)

of the Illinois River. Near by were also the remains of a necklace composed of alternate pearls and bone beads. The McEvers Mound in Montezuma, Pike Co., Illinois, also yielded, according to D. I. Bushnell, the excavator, a group of forty-five pearls, including one of beautiful lustre weighing fifty-two grains.[121]

The use of pearls as ornaments, and for depositing with the remains of persons of distinction, was also customary among the Indian tribes of Virginia. The accounts of early explorers and colonists furnish us with many details as regards the burial of pearls with the dead and their use in religious rites. The first English colonists found the Indians of Virginia esteeming pearls among their favourite treasures and ornaments. An excellent account of these Indians is given by Charles C. Willoughby in the "American Anthropologist" (vol. ix., 1907). This article is of great interest as dealing with the habits and customs of the tribes occupying tidewater Virginia at the time of the first colonization. The Indians, a branch of the Algonquian stock, formed a powerful confederacy under Powhatan comprising some thirty tribes. To the greater chiefs tribute was paid in pearls, copper, beads, skins, etc. Pearls were also used to adorn the native clothing, as well as for necklaces and ear-pendants. Strachey, an early explorer, reports having seen "manie chaynes and braceletts (of pearls) worne by the people, and wee have found plentie of them in the sepulchers of their kings, though discoloured by burning the oysters in the fier, and deformed by grosse boring." The writings of this and other explorers give curious accounts and descriptions of the "temples" within which, in a sort of sanctuary or "chancel," were kept the dried bodies of deceased chiefs, and an image of the god, called Okee, made in the shape

[121] Kunz and Stevenson, *op. cit.*, p. 509.

of a man, "all black, dressed with chaynes of perle." The process of preserving the remains of the chiefs is described as follows: "After the body had been disemboweled, the skin was laid back and the flesh was cut away from the bones. When this operation was completed, the skeleton, held together by its ligaments, was again inclosed in the skin, and stuffed with white sand, or with 'pearle, copper, beads, and such trash sowed in a skynne.' It was then dressed in fine skins and adorned with all sorts of valuables, including strings of pearls and beads. The same kinds of treasures were also deposited in a basket at the feet of the mummy."[122]

The chroniclers of De Soto's expedition to Florida in 1539, speak of almost fabulous quantities of pearls in the possession of the Indians of the parts traversed by them. One Portuguese narrator says, "they obtained fourteen bushels of pearls" from a certain sepulchre, and it is stated that a common foot soldier had "a linen bag, in which were six pounds of pearls," and pearls are elsewhere spoken of that are "as large as filberts." Garcillasso de la Vega says "while de Soto sojourned in the province of Ichiaha the cacique visited him one day and gave him a string of pearls about two fathoms long. This present might have been a valuable one if the pearls had not been pierced, for they were all of equal size and as large as hazelnuts."[123]

"As in Cleopatra's time in Egypt," says Streeter,[124] "so in Florida, the graves of the kings were decorated with pearls. Soto's soldiers found in one of their temples

[122] *Ibid.*, pp. 486-8.

[123] Stearns, *Rept. U.S. Nat. Mus.*, 1887 (1889), pt. ii.. p. 279, quoting Irving's "Conquest of Florida"; see also Grace King, "De Soto and his men in the Land of Florida," New York, 1914, pp. 136-143, etc.

[124] Streeter, *op. cit.*, pp. 45-6.

great wooden coffins, in which the dead lay embalmed, and beside them were small baskets full of pearls. The temple of Tolomecco, however, was the richest in pearls; its high walls and roof were of mother-of-pearl, while strings of pearls and plumes of feathers hung round the walls; over the coffins of their kings hung their shields, crowned with pearls, and in the centre of the temple stood vases full of costly pearls."

Though the various accounts relating to the abundance of pearls in Florida are probably somewhat exaggerated, there seems sufficient evidence to prove that pearls of some value were in the possession of the wealthier tribes. That they were met with in some numbers in graves seems also to be a reliable statement.[125]

As to the source of these pearls, most of the narratives refer to them as coming from the coast of the South Sea or Gulf of Mexico. While possibly this was the case with some of the pearls, it is more probable that the majority came from the freshwater shells (Unios) of the inland lakes and rivers.

In Alabama, pearls pierced for stringing have been found in several of the mounds at Moundville by Clarence B. Moore, along with a sheet-copper pendant bearing a perforated pearl nearly 7 mm. in diameter, and an elliptical gorget of sheet-copper decorated with a pearl.[126] Perforated pearl beads have been also found in the Etowah Mound, located in Barton County, Georgia.[127]

At the pre-Columbian capital of Copan, in Western Honduras, evidences have been met with pointing to a very early use of pearls. G. B. Gordon[128] tells us that in

[125] This question is fully discussed by Kunz and Stevenson (*op. cit.*, pp. 252-259).

[126] Kunz and Stevenson, *op. cit.*, p. 493.

[127] W. K. Moorehead, "Prehistoric Implements," N. Y., 1900, p. 376.

[128] G. B. Gordon, "The Mysterious City of Honduras," *The Century Magazine*, vol. lv., p. 417.

exploring a number of isolated tombs beneath the pavement of courtyards and under the foundations of houses at this city, human remains were found associated with various articles of use and adornment. "The beads, ear-ornaments, medallions, and a variety of other ornaments, usually of jadeite," Gordon remarks, "exhibit an extraordinary degree of skill in the art of cutting and polishing stones, while the pearls and trinkets carved from shell must have been obtained by trade or by journeys to the coast." Thomas Gann, of Yucatan, also states that "ornaments such as beads, gorgets, and ear-pendants, made from the pearly shell of both the oyster and the conch, are of common occurrence in many sepulchral mounds in British Honduras and Yucatan."[129]

In Guatemala no pearls appear to have been observed in the pre-Columbian graves, but marine shells, whole, and elaborated in connection with jadeite beads have been found.[130]

On the Pacific coast of Mexico, and especially along the coast of Lower California, quite extensive pearl-fisheries are prosecuted. The fisheries on the Mexican coast appear to have been in existence for centuries. European knowledge of these resources dates from the conquest of Mexico by Cortés about 1522. Native chiefs were found living in primitive huts along the sea-shore, with quantities of beautiful pearls lying around, and from a tribe near the present site of Hermosillo, in the State of Sonora, Cortés secured quantities of the gems.[131]

Pearls were highly appreciated by the Aztec kings, and the gems were employed to decorate statues of the gods and their temples, as in India. The temple in which

[129] Kunz and Stevenson, *op. cit.*, p. 511.

[130] *Ibid.*, p. 511.

[131] Kunz and Stevenson, *op. cit.*, p. 241.

Montezuma used to pray at night, is said to have had walls of beaten silver and gold, decorated with pearls and precious stones.[132] Humboldt refers to a statue of a Mexican priestess in basalt, whose head-dress is ornamented with pearls.[133] Bateman[134] likewise mentions an ancient Mexican horned head-dress, inlaid in mosaic with turquoise, malachite, coral (?), and mother-of-pearl. Pearl-shell also appears to have been used as an inlay in the Mexican mosaic masks in the British Museum, which are pre-Columbian in origin. One of these, a plain mask, is of special interest as the eyes are of mother-of-pearl.[135]

Mrs. Zelia Nuttall, in a letter to Kunz and Stevenson,[136] writes "that pearls are not mentioned either as articles of tribute or of decoration in ancient Mexican codices; possibly a lack of fine, hard instruments with which to drill holes in pearls may have caused them to be comparatively little used in personal adornment. Neither do they appear to have been found incrusted in prehistoric objects, and we have no written evidence of their having been used in this way. We do not know of any instances of the wearing of pearls by the Indian women, but the women of the higher classes used to wear them profusely, more especially drop-earrings and pendants."

W. H. Holmes,[137] quoting from Davis' "Spanish Conquest of New Mexico," says: "In travelling north along the west coast of Mexico, the Friar Niza encountered Indians who wore many large shells of mother-of-pearl about their necks, and farther up towards Cibola, the

[132] Streeter, *op. cit.*, p. 45; Kunz and Stevenson, *op. cit.*, p. 23.

[133] Humboldt, *op. cit.*, i., p. 191.

[134] Bateman, "Catalogue of Antiquities." Bakewell, 1855, p. 236.

[135] Kunz and Stevenson, *op. cit.*, p. 510.

[136] *Ibid.*, p. 433.

[137] W. H. Holmes, "Art in Shell of the Ancient Americans." *Second Annual Report of the Bureau of Ethnology*, Washington, 1883, p. 256.

inhabitants wore pearl shells upon their foreheads." These facts are of interest as recalling the identical use of pearl shell in some of the Pacific Islands—Torres Straits Islands, Solomon Islands, etc.,—and in Ancient Egypt (*supra* p. 5).

According to the reports of travellers, the natives of Mexico, in the 18th century, still appreciated pearls, using them along with other jewels to adorn their noses, lips, ears, necks and arms.[138]

On the coast of Venezuela extensive pearl fisheries have been carried on since before the time of Columbus. On entering the Gulf of Paria, in 1498, this voyager found the natives in possession of numerous pearls which they were wearing on their necks and wrists. They were also seen engaged in pearl fishing by the Spaniards, and it is curious to note that the views of the Indians regarding the origin of the gems were identical with those which obtained for ages in the Old World. They regarded them as congealed dewdrops, which had been caught by the gaping oysters.[139]

Another famous American pearl fishery is that of the Gulf of Panama, referred to by many early Spanish writers. The pearl resources of this region were first made known by Balboa's immortal journey in 1513 across the Isthmus of Panama to the Pacific. Having reached the Pacific, Balboa proceeded along the coast and found the Indians in possession of gold and pearls, the latter being used to decorate their paddles. The pearl fishery appeared to be the principal source of income and wealth of the Indian chiefs.[140]

Among the pre-Columbian antiquities found in Ecuador associated with burials was a little box or receptacle

[138] G. A. Cooke, *op. cit.*, ii., p. 141.

[139] Streeter, *op. cit.*, p. 223.

[140] Kunz and Stevenson, *op. cit.*, p. 235.

cut from a Cassis shell, the cover of which was a fragment of the valve of the pearl-oyster.[141] This and other discoveries of pearls in that country by the same investigator point to the existence of pearl fisheries on this coast many centuries ago. It is reported that Manta, in the Province of Manabi, is the place where the Incas obtained the splendid gems found in the temples and palaces of Peru by the Spaniards.[142]

The Incas of Peru held a curious belief concerning pearls; they regarded them as the "eggs" of the pearl-producing shell-fish.[143]

The artificial eyes of their mummies have been spoken of as pearls, but, according to Tschudi, they are the dried eyes of the cuttle-fish (*Loligo gigas*).[144]

Rivero and Tschudi[145] inform us that the Peruvians were accustomed to ornament their textiles by sewing upon them leaves of gold and silver, or small pieces of mother-of-pearl, etc.; and in speaking of the Huaca of Misa, they say that a stone idol, with mother-of-pearl, was formerly met with here, along with mummies, cloths, pieces of gold and silver, etc.

Much further information could be given concerning the use of pearls and pearl-shell, but want of space makes it necessary to bring this already somewhat lengthy paper to a conclusion. Before doing so, however, mention might

[141] M. H. Saville, "Antiquities of Manabi, Ecuador," Contributions to South American Archæology, N. Y., 1910, vol. ii., p. 177.

[142] Kunz and Stevenson, *op. cit.*, p. 282.

[143] W. J. Dakin, "Pearls," Cambridge, 1913, p. 8.

[144] Tryon, "Structural and Systematic Conchology," vol. ii., 1883, p. 24. Cuttle-fish eyes are strung, as pearls for necklaces, on the shores of Sicily and Naples; and the natives of the Sandwich Islands have imposed them on the Russians as pearls. Johnston, *op. cit.*, p. 62 footnote.

[145] M. E. Rivero and J. J. von Tschudi, "Peruvian Antiquities," New York and London, 1857, pp. 224 and 266 (Translation by F. L. Hawks).

be made of an interesting reference to the use of pearl-shell among the Indians of southern Alaska.

In his description of Port des Francais, the celebrated navigator, M. de la Perouse, remarks on the ability of the Indians of this neighbourhood to inlay boxes of elegant form with mother-of-pearl. Unfortunately, he does not state whether the true pearl-shell was employed, or that of the abalone (*Haliotis*). This, however, is not of very great importance, as the point of chief interest is the fact that the use of the pearl-shell for inlay purposes is strongly suggestive of Asiatic influence. Other details, given by Perouse, concerning the many curious customs of these same people, such as 'platform burials,' the 'special preservation of the head of the deceased and cremation of the body,' etc., provide equally suggestive evidence of this.[146]

The *Haliotis*, which also yields good pearls, was applied to many varied uses by other savage peoples on the Pacific coast of America, especially in California, where these pearly shells have been found in great numbers in the burial places of the ancient tribes. Putnam records the discovery of several objects inlaid with *Haliotis* shell in graves on the islands of Santa Catalina and of Santa Cruz, the pieces of shell being held in place by a thin cement of asphaltum.[147]

The remarkable resemblance between the shell-art of ancient California and that of the Pacific Islands is very significant.

[146] G. A. Cooke, *op. cit.*, ii., p. 106; see also Niblack, "The Coast Indians of Southern Alaska and Northern British Columbia." *Rept. U.S. Nat. Mus.*, 1887-8 (1890), pp. 225-386

[147] F. W. Putnam, "U.S. Geographical Survey west of the 100th Meridian : vol vii., Archæology." Washington, 1879, pp. 232-3.

Manchester Memoirs, Vol. lx. (1916), *No.* **13**.

XIII. The Use of Cowry-shells for the Purposes of Currency, Amulets, and Charms.

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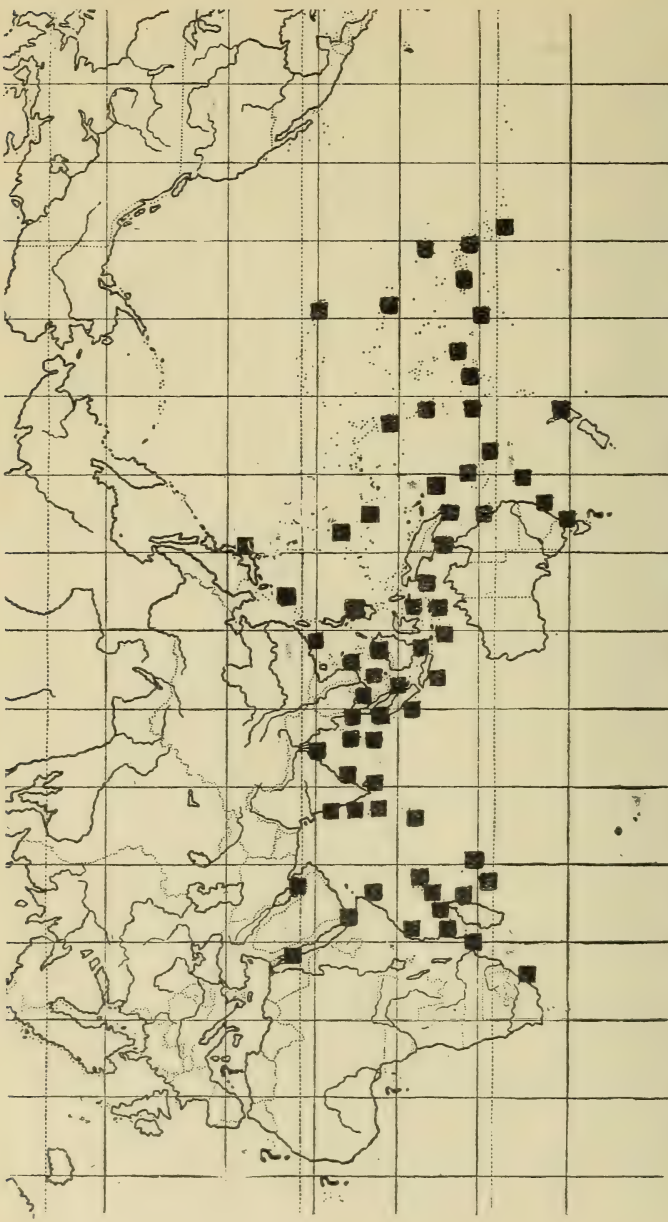
Of the many varieties of shells used for currency and as amulets, by far the most familiar and extensively employed are the cowries, especially the money-cowry *(Cypræa moneta)* and the ring-cowry *(Cypræa annulus)*. (*Fig.* 1, *A* & *B*) The small size, shape, and substance of the latter renders them peculiarly adapted for use as money, and no other species of shell or form of shell-money has had so wide-spread and general use. They are distinguished by the fact that they can be and are used in a natural state, most other forms of shell-money being made from portions of larger species. Though known to science under two distinct names, the difference between the two forms is so slight that by some authorities they are considered as merely the extremes of one variable mollusc.[1] Both forms are inhabitants of Indo-Pacific seas, and the specimens used as currency are derived mainly from the Persian Gulf, Maldive Islands, Ceylon, the Malabar Coast, the Sooloo Islands (between the Philippines and Borneo), and other East Indian Islands; also from various parts of the

[1] Melvill and Standen, *Journ. of Conchology*, ix., 1899, p. 236; S. R. Roberts, "Monograph of the Family Cypræidæ," in Tryon's "Manual of Conchology," vol. vii., 1885, p. 179.



Map A, showing the recorded range of *C. moneta* and *annulus*. The question marks denote doubtful occurrences; presence at these places may be due to the foundering of ships carrying these shells.

Map B, showing distribution of the Use of Cowries.
■ = *Cypræa moneta-annulus*. O = Other Cowries.

East African coast, ranging from Ras Hafun (near the Gulf of Aden) to Mozambique. As currency these shells circulate not only through Southern Asia and certain of the Pacific Islands, but far into the African continent.

The term cowry, cowrie, or gowrie, is said by Dr. J. Cosmo Melvill[2] to be derived from a Greek word meaning "a little pig," and according to Liddell and Scott this was probably the shell used by the Athenian dicasts in voting. "Following the example of the Greeks, the Romans termed these little shells *porci* or *porculi*, whilst the French nowadays term them *pou de mer*; and in the word *porcelain* we can also trace the same derivation" (Melvill, p. 186). Deniker,[3] however, says the term cowry, cowrie, or cauri, appears to be a corruption of the Sanskrit word *Kaparda*, whence *Kavari* in the Mahrattan. Murray's dictionary[4] gives the Hindī and Urdū equivalents as *Kauṛī* (or *Kaudī*). In Monier Williams' "Sanskrit-English Dictionary"[5] the following interpretations are given: "*Kaparda, as*: a small shell or cowrie used as a coin and as a die in gambling, *Cypræa moneta*; braided and knotted hair, especially that of S'iva (knotted so as to resemble the cowrie shell). *Kapardin, ī, inī, i*: shaggy; wearing braided and knotted hair like a cowrie shell; epithet of Rudra, of Pūshan, of the descendants of Vasishtha and of Durgā; (ī) name of S'iva; name of one of the eleven Rudras."

The Portuguese called the cowry *Boudji* or *Boughi*; the inhabitants of the Maldives, *Boli*; the Siamese, *Bios* (which means shell in general in Thaï). By the Arabs it is known under the name *ouoadda* or *vadaat* (Deniker, *op. cit.*).

[2] J. C. Melvill, "A Survey of the genus Cypræa," *Memoirs and Proc. Manch. Lit. & Phil. Soc.*, 4th Ser., vol. 1. (1887-8), pp. 184-252.

[3] Deniker, "Races et peuples de la Terre," Paris, 1900, p. 324 footnote.

[4] Murray, "New English Dictionary."

[5] Oxford, 1872, p. 201.

The use of cowries as currency and as amulets or charms has been frequently discussed in ethnological memoirs. From this literature it is clear, though the fact has not always been realised or sufficiently emphasised by the authors, that cowries have been for ages regarded and even reverenced as charms in hunting and fishing, and as amulets against the evil eye. In fishing, especially in the Pacific Islands, they are attached to the nets to ensure luck, being misnamed "net-sinkers" by many writers on ethnology. They have been, and in many places are still, associated with marriage, with the object of securing communion with the spirit of fertility, supposed to be indwelling in the cowry. In like manner they are used in some places as offerings to rivers and springs in order to ensure that the rivers will run and springs flow.

In the following pages an attempt is made to show some of the many uses of cowries in different parts of the world. The remarkable manner in which some of the customs, in which cowries play an important part, crop up in widely-scattered localities is very significant, and goes far to prove a common centre of origin for these practices. It is altogether unreasonable to assume that exactly similar customs of so peculiar and wholly arbitrary a nature and identical beliefs concerning the cowry could have arisen independently among isolated groups of people.

The best and most comprehensive work on the subject of shell-money is that by Dr. O. Schneider, on "Muschelgeld-Studien."[6] This work contains some 180 pages dealing with the subject, of which about 72 pages are devoted to an excellent summary of the extensive literature relating to cowry-currency. Some use has been made of this work in the compilation of the present communication, as will

[6] Dr. Oskar Schneider, "Muschelgeld-Studien" (Nach dem hinterlassenen Manuskript bearbeitet von Carl Ribbe). Herausgegeben vom Verein für Erdkunde zu Dresden. Dresden, 1905.

be seen by the footnotes. Much further information, however, not noted by Schneider, is embodied here, more especially with regard to the use of cowries in Ancient Egypt, Eastern Asia, North America, and many other places.

Cowries appear to have been appreciated and used as amulets at a very early period in Egypt. Both *Cypræa moneta* and *Cypræa annulus*—the forms so universally used for currency—have been discovered, along with other cowries, in Pre-dynastic burials, and both forms have been found repeatedly in later graves in Egypt and Nubia. According to Lortet and Gaillard,[7] the following species of cowries have been found at Karnak: *Cypræa vitellus*, *C. tigris*, *C. pantherina*, *C. camelopardalis* (= *melanostoma*), *C. arabica*, and var. *histrio*, *C. erythræensis*, *C. caput-serpentis*, *C. moneta* and *C. annulus*—all species which occur to-day in the Red Sea. The larger forms are perforated near one end as if for use as pendants. The examples of *C. moneta* and *C. annulus* are of peculiar interest from the fact that they have been rubbed down on the back or convex side—a custom which is still in vogue among the East African people to-day. Of further interest is the figure given by the same authors of a reproduction in diorite of a *Cypræa moneta*. This object, which is perforated for suspension, was found in the necropolis of Rizakat, near Gébélên, Upper Egypt. In a tomb (D 114) at Abydos, of xviiith dynasty date, large numbers of *Cypræa annulus* were discovered, all of them having been rubbed down on the back, as at Karnak.[8] The same

[7] Lortet & Gaillard, "La Faune Momifiée de l'ancienne Egypte: Mollusques," *Arch. Mus. d'Hist. Nat. de Lyon*, vol. 10, Lyon, 1909, pp. 108-111; see also List of Species, pp. 310-311.

[8] T. E. Peet & W. L. S. Loat, "The Cemeteries of Abydos," pt. III. 1912-1913, 35th *Mem. Egypt. Explor. Fund*, 1913, p. 30, pl. xii., figs. 6 & 9. (The Series is now in the Manchester Museum).

species, *C. annulus* is also recorded from Koptos[9] and Nagadeh, probably of pre- or proto-dynastic date;[10] it is also associated with other objects, such as papyrus charm pendants, uzat eyes, etc., strung on knotted cords found at Kafr Ammar (xxiii—xxvth dynasty).[11] Reisner in "The Archaeological Survey of Nubia (1907-8)"[12] gives a figure of a small cowry, rubbed down on the back, which is probably *C. annulus*; it is recorded as occurring in the C-group, New Empire, and later graves. *Cypræa moneta* occurs in the list of shells found in graves at El Amrah (Pre-dynastic).[13] Other species of cowries discovered in Egyptian graves are as follows: *Cypræa caurica*? "Pan-Graves" at Balabish;[14] *C. arabica*, Koptos; *C. carneola*, Ballas; *C. erosa*, Ballas; *C. caurica*, Ballas?; *C. pantherina*, Nagadeh;[15] *C. arabica* var *reticulata* Toukh, Upper Egypt.[16]

These discoveries of cowries in Ancient Egyptian graves are of great interest as being the earliest evidence of a special appreciation of these shells. That they were worn as amulets by the Egyptians cannot be doubted from the fact that so many are perforated for suspension.

The discovery of so many specimens of the smaller

[9] Flinders Petrie, "Six Temples at Thebes, 1896," London, 1897, chap. x., p. 30.

[10] *Idem.* "Amulets," 1914, p. 27, pl. xiv., f. 107b.

[11] *Ibid.*, p. 29, pl. xvii., f. 131b, 131c.; pl. xviii., f. 131e, 131f.; pl. xix. f. 131g.

[12] Vol. i., Archæol. Rept., Cairo, 1910, pl. 66, f. 7 and pl. 70, f. 1. The C-group belongs to a period corresponding to the Middle Kingdom in Egypt.

[13] D. Randall-Maciver & A. C. Mace, "El Amrah and Abydos 1899-1901," London, 1902, p. 49.

[14] G. A. Wainwright, "The Excavations at Balabish," *Journ. of Egypt. Archæol.*, ii., Oct., 1915, pl. xxv., f. 2 (named from photograph). "Pan-Graves" are Nubian interments in Egypt and may belong to the period from 2000 B.C. onwards.

[15] These five recorded by Flinders Petrie (*fide* Lortet & Gaillard, *op. cit.*, pp. 310-311).

[16] De Morgan (*fide* Lortet & Gaillard, *op. cit.*, p. 310).

form, *C. annulus*, together in one grave (D 114) at Abydos, would seem to suggest the possibility that cowries may have been adopted as a form of currency at that early date. According to Del Mar,[17] Egypt "appears to have conducted its exchanges with cowries and scarabs, supplemented possibly at later dates by Lydian or Greek coins for foreign commerce, until the Persian conquest, when it was supplied with a national coinage, probably of very limited extent, by Cambyses and Darius." He further remarks: "The Indians who traded with Egypt used cowries for money; the Chinese, who also traded with Egypt at a very remote period, used 'tortoise' (probably cowrie) shells for money." (Del Mar, p. 147.)

The money-cowry (*Cypræa moneta*) has been found at the famous cemetery of Koban, upon the northern slope of the Caucasus, almost midway between the Black and Caspian Seas, along with bronze and other antiquities.[18] It has also been recorded from a sandy layer above the Tertiaries at Frankfurt-on-Main by Dr. W. Wenz, who reports the existence of extensive prehistoric settlements of different periods in the immediate neighbourhood.[19] Another interesting record is that of Dr. H. Stolpe, who states that, among the foreign objects (Cufic money, etc.) found in the Island of Björkö, were many Upper Silurian fossils from Gothland, and Cretaceous fossils from Skane, also some shells of molluscs from the west coast of Sweden. But the most important shells were five examples of the money-cowry, *Cypræa moneta*.[20] Speci-

[17] Del Mar, "A History of Money," London, 1885, p. 149.

[18] "A Guide to the Antiquities of the Bronze Age" (British Museum), 1904, p. 129; see also "Materiaux pour l'hist. prim. et nat. de l'homme," 2nd ser., xiii., June, 1882, p. 260.

[19] *Nachr. Deutsch. Mal. Ges.*, 1911, p. 104.

[20] *Congrès internat. d'Anthropol. et d'Archéol. Préhist.*, 1874, vol. ii., Stockholm, 1876, pp. 619-29.

mens of the ring-cowry (*C. annulus*) were found by Dr. Layard in the ruins of Nimroud,[21] and others of this form, *rubbed down on the back*, were met with in graves at Shusha, in Transcaucasia, associated with numerous carnelian beads, perforated animals' teeth, stone implements, and bronze and iron objects.[22]

Another find of special interest was made by Dr. Truhelka at the pile-dwelling of Donja Dolina, on the bank of the Save (Bosnia). Here urn-burials were met with in under-ground vaults which contained the incinerated remains of bodies and a wealth of grave-goods. From the valuable nature of the latter it would appear that the cremated persons were of great social distinction. The objects comprised fibulæ, beads of glass, amber, and enamel, and other articles characteristic of the late Hallstatt period. One of the chief objects of interest was "one urn, which contained a necklet composed of several hundreds of beads of amber, enamel, coloured glass, seven cowrie shells, two perforated teeth, and a large bead of clay without any ornamentation."[23]

Dr. Schneider (*op. cit.*, p. 115), quotes many interesting discoveries of cowries in ancient graves, chiefly in the neighbourhood of Danzig—the great amber-producing region. According to this authority they were found at Marienhausen, in the government of Witebsk, where in 1879, some 50 specimens occurred in a grave, doubtless belonging to Slavonic times; also in old pagan Lithuanian graves, at Rügenwalde in Pomerania, in the urn of a "giant's-grave" at Stolpe, on the well-known Pomerellen

[21] S. P. Woodward, "Manual of the Mollusca," Reprint of 4th Ed., London, 1890, p. 233.

[22] *Verhandl. der Berliner Gess. f. Anthrop.*, 1892. pp. 566-8; 1894, p. 216.

[23] R. Munro, "Palæolithic Man and Terramara Settlements in Europe," Edinburgh, 1912, p. 473.

face-urns as earrings; further, several burnt and fractured specimens of *Cypræa annulus* were found in an urn from a stone-cist at Jakobsmühle near Mewe, and in a face-urn at Rheinfeld near Carthaus; *Cypræa moneta* in a grave near Praust, a *Cypræa annulus*, prepared as an amulet, at Seehof near Kulmsee, *C. moneta* as earrings on face-urns at Stangenwalde and at Wilschen in Berent district, as well as in burnt condition in a face-urn at Czapeln; finally, several specimens of a *Cypræa*, too badly damaged by fire for exact specific determination, occurred in a face-urn at Bockau on the river Radaune, West Prussia.

In an essay by Dr. H. Conventz, of Danzig, on the introduction of cowries and related sea-shells as ornament in West Prussia in prehistoric times,[24] further mention is made of discoveries, which he refers to the first century B.C, of *Cypræa annulus* in face-urns at Rheinfeld, in Carthaus district, Suckschin, in Higher Danzig district, and Jakobsmühle, in Marienwerder district, as well as in an ordinary urn at Fronza, in Marienwerder district; and of *Cypræa moneta* in the ears of urns from Wilschen, Berent district, and Stangenwalde, Carthaus district, and in a face-urn from Praust, near Danzig; further, of "Roman times," which corresponds to the 1st century A.D., *Cypræa annulus* attached to bronze-strip as a charm, found near Elbing and Seehof, in Briesen district; finally, of the "Arabic-norse epoch," a perforated *C. moneta* on the neck of a skeleton in the grave-field near the Grutschno Burgwälle, in the Schwetzer district.

Cowries of larger dimensions than *Cypræa moneta* and *C. annulus* have been met with in pre-historic pit-dwellings and Saxon graves in our own country; in Franco-Merovingian graves in France; in the Gallo-

[24] *Correspondenzblatt d. deutsch. Gesell. f. A. E. u. U.*, xxxiii. no. 2, 1902, (*fide* Schneider, *op. cit.*, p. 115)

Roman necropolis of Trion, at Lyons ; and in Pompeii, as well as in other places.

The complete outer lip of *Cypræa tigris*, a species occurring in the Indian Ocean and Red Sea, has been recorded by J. R. le B. Tomlin, from a pre-historic pit-dwelling at St. Mary Bourne, Hants.[25] The same handsome species is recorded by M. Locard from the Gallo-Roman necropolis of Trion, and by Monterosato from Pompeii.[26] *Cypræa pantherina*, a Red Sea shell, has been found in Saxon women's graves, excavated on Kingston Down, and Sibertswold Down, in Kent,[27] and in a grave near Wingham, Kent.[28] It has also been recorded (under the name *Cypræa vinosa*) by Dr. Ph. Dautzenburg from the Franco-Merovingian necropolis of Nesles-lez-Verlincthun (Canton de Samer).[29] Dr. Dautzenburg also refers in the same paper to a record by M. l'Abbé Henri Debout of the presence of this shell (erroneously referred to *C. arabica*) in a sepulchre at Tardinghen ; and from Dr. Tiberi's Memoir on the shells met with in the excavations at Pompeii,[30] we learn that many examples of this species were found, and that the shell in question was an amulet which the women carried in order to prevent sterility.

In a footnote in Dr. Schneider's paper (*op. cit.* p. 116), reference is made to a description, by Dr. Koehl, of Merovingian graves at Weisoppenheim, near Worms, where cowries were found alongside the bodies of several women, either hanging from a girdle, or sewn to their dresses. Unfortunately, the specific name of the shell is

[25] *Journal of Conchology*, vol. 13, 1912, p. 251.

[26] *Fide* Tomlin, *op. cit.*

[27] Faussett's "Inventorium Sepulchrale," 1856, pp. 68, 92 & 133. (See also J. W. Jackson, *Journ. of Conch.*, vol. 13, 1912. p. 307, for discussion of species).

[28] "Archæologia," vol. 30, p. 551.

[29] *Journ. de Conchyliologie*, vol. liv., 1906, p. 260, figs. 1 & 2.

[30] "Le Conchiglie Pompeiane," Napoli, 1879.

not given. In the same footnote mention is made of the discovery of a large *Cypræa* in an old German grave at Entibühl, and of an Indian Ocean *Tritonium*,[31] filled with worked flints at Brunswick.

A further discovery of a shell from the Indian Ocean, *Ovulum ovum*, closely akin to the cowries, was made in a Gothlandic tomb. This specimen had a hole at one end in which was still fixed a little ring of bronze wire.[32]

In Crete, black cowries, probably dark forms of *Cypræa pantherina*, were found in excavating the rooms of Mycenæan houses.[33]

In a paper on "Cave Explorations at Gibraltar in September, 1910,"[34] Dr. W. L. H. Duckworth records the discovery of a Mediterranean cowry, *Cypræa pyrum*, in excavating Cave S. The specimen is remarkable on account of an artificial perforation at one end, as if for suspension as an amulet. On the evidence of the human remains and the pottery found, the cave is assigned to the Neolithic period. In the same cave were found specimens of *Purpura hæmastoma* with the apical parts fractured in a curious manner, suggesting that the mollusc had been used for the preparation of its distinctive product, the Tyrian Purple.[35]

A perforated specimen of *Cypræa pyrum* is recorded by Lartet and Christy[36] from La Madelaine cave, Périgord, along with other perforated shells and teeth of animals, but in this case the cowry is said to be a fossil, probably

[31] ? *Triton*, the shell employed as a trumpet in many places.

[32] Hans Hildebrand. "The Industrial Arts of Scandinavia," (South Kensington Museum Art Handbook), 1882, p. 40.

[33] *Ann. Brit. Sch. Athens*, ix. (1902-3), pp. 291 and 335.

[34] *Journ. Roy. Anthrop. Inst.*, xli., 1911, p. 362, pl. xl., fig. 4, 5.

[35] See my paper on this subject in *Manch. Memoirs* (*Lit. & Phil. Soc.*), lx. (1916), No. 7.

[36] "Reliquiæ Aquitanicæ," London, 1875, p. 48 (Description of the Plates), pl. v., fig. 15.

from the Faluns of Touraine. Mention is also made of a collection of objects from the Cave of Bruniquel, comprising carnivore teeth and perforated marine shells, including a *Cypræa* an inch in length, not improbably derived from the Miocene beds of the Garonne.[37]

Since Christy's diggings in Laugerie-Basse,[38] this cave has yielded many other interesting objects, including two species of Mediterranean cowries, perforated for use as pendants. Particulars of the discovery of the cowries are given in a paper by Massenat and others[39] dealing with the finding of a human skeleton (the so-called homme ecrassé) in this cave. The latter seems to have been a ceremonial interment in the contracted posture. The situation of the objects which accompanied the skeleton was studied with scrupulous attention and a score of shells were found. These were determined by Mortillet as belonging to two different species of Mediterranean cowries, *Cypræa pyrum*, Gmelin (or *rufa* Lam), and *Cypræa lurida L.* The most interesting fact concerning them is that they were arranged in pairs upon the body; two pairs on the forehead, one near each humerus, four in the region of the knees and thighs, two upon each foot. The discoverer dismisses the idea of a necklace or bracelets and suggests they were intended to adorn a garment. Each cowry was pierced with a notch.

Cowries have also been found in the celebrated Mentone Caves alongside human skeletons, which can with

[37] *Ibid.*, p. 179 (Text).

[38] *Ibid.*, p. 288 (Text).

[39] E. Massenat, Ph. Lalande & Cartailhac, "Découverte d'un squelette humain de l'âge du renne à Laugerie-Basse (Dordogne)." *Comptes Rendus de l'Acad. des Sciences*, vol 74, 1872, pp. 1060-3; also Paul Girod and E. Massenat, "Les Stations de l'Age du Renne dans les vallées de la Vézère et de la Corrèze—Laugerie-Basse," Paris, 1900, pp. 24-5. Sollas (Ancient Hunters, 2nd Ed., 1915, p. 509, fig. 288) gives a figure of this interesting burial, with the associated shells. (After Cartailhac).

considerable confidence be correlated with those found in the valley of La Vézère, at Laugerie-Basse, Cro-Magnon, Gourdan, and Chancelade. Villeneuve[40] records, amongst other shells, one *Cyprœa.* from an occupation level (Foyer D), 3m. 15. from the surface, in La Grotte des Enfants. The specific name, unfortunately, is not given. On the same level a remarkable find was made of *Cassis rufa*, an Indian Ocean shell.[41]

At Barma Grande, another of the Mentone Caves, various kinds of ornaments of teeth and bone, and perforated shells of *Nassa neritea*, were found, in 1892, near the head of one of the skeletons discovered there; but the most interesting and remarkable find was that "on each thigh bone above the knee was a perforated cowry."[42] The body is said to be that of an old man. It is of interest to note that all the skulls found here are stated to be of

[40] "Les Grottes de Grimaldi (Baoussé—Roussé)," Tome i., Fasc. i. "Historique et Description." By M. L. de Villeneuve (p. 65). (Imprimerie de Monaco, 1906).

[41] *Ibid.*, Tome i. Fasc. 2. "Geologie et Paléontologie." By Prof. Marcellin Boule (p. 123); In a footnote to this page, G. Dollfus remarks: "*Cassis rufa* L., an Indian Ocean shell, is represented in the collection at Monaco by two fragments; one was found in the lower habitation level D; the other is probably of the same origin. The presence of this shell is extraordinary as it has no analogue in the Mediterranean, neither recent nor fossil; there exists no species in the North Atlantic or off Senegal with which it could be confounded. The fragments have the traces of the reddish colour preserved and are not fossil; one of them presents a notch which has determined a hole that seems to have been made intentionally. The species has not yet been found in the Gulf of Suez nor in the raised-beaches of the Isthmus. M. Jousseaume has found it in the Gulf of Tadjoura at Aden, but it has not yet been encountered in the Red Sea nor in the raised-beaches of that region. The common habitat of *Cassis rufa* is Socotra, besides the Seychelles, Madagascar, Mauritius, New Caledonia and perhaps Tahiti. The fragments discovered at Mentone have therefore been brought from a great distance, at a very ancient epoch, by prehistoric man."

[42] Munro, "Palæolithic Man and Terramara Settlements in Europe." Edinburgh, 1912, p. 163. [At p. 235, perforated teeth and shells, *Nassa*, *Cyprœa*, *Pectunculus*, etc., are mentioned as being found at the Rock-shelter of Cap-Blanc (Laussel), Dordogne].

the Cro-Magnon type, and that all the bodies had been definitely interred. The discovery of cowries and the relation of these to the body, forms an interesting parallel to the Laugerie-Basse burial referred to above.

The association of perforated cowry shells with men belonging to the Cro-Magnon group is not without interest when it is remembered that these people were members of our own species—*Homo sapiens*, and quite distinct from the earlier Neanderthal people. That they were men capable of formulating ideas and endowed with an artistic sense is unquestionable. The skeletons of this race all seem to have been ceremonially interred, which certain writers regard as implying that they were not without some idea of religion. The fact that they used perforated shells, teeth, and pendants, as amulets, also supports this conclusion. But, of course, the validity of the inference depends upon what is meant by the term "religion."

How this race came into the south of Europe and where it came from is not easy to determine; but the slender evidence at present available disposes us to look to North Africa as its immediate source. It seems possible that these people may have been an early sporadic invasion from, or at least have been in direct or indirect contact with, the region where civilisation first developed—the valley of the Nile and Western Asia.

The skull of the Cro-Magnon man has so many points of similarity to that of Neolithic man in England, that, in defiance of the archæological evidence, the former race was judged at one time to belong to the Neolithic period. Leading authorities now agree in relegating it to an earlier time, which includes the Magdalenian period.[43]

[43] The culture of the Cro-Magnon race is certainly quite distinct from that of the Lower Palæolithic people—Neanderthal man, and on this account Dr. Elliot Smith has suggested the term "Neoanthrophic phase of culture," in order to give specific emphasis to the profound break in human history

As Dr. G. Elliot Smith has pointed out,[44] many similarities exist between Magdalenian and the later Azilian implements, and also of both of these to those of Pre-dynastic Egypt. This suggests the possibility of the Magdalenian period in the west being *approximately* contemporaneous with the pre-dynastic period in Egypt, and that the Neolithic period in Western Europe did not begin long before the third millennium B.C.

In connection with the above it is of interest to note that the cowry is frequently associated with pre-dynastic burials in Egypt.

The numerous discoveries of cowries detailed above serve to show the migrations or intercourse of early peoples. They are not to be regarded as evidence of the shells, even the smaller kind, having been employed as currency in the localities where they were found, nor indeed are they to be looked upon as having been worn from purely æsthetic motives. Their presence may be explained by the part cowries played in early times as symbolic of the generative forces of nature. The shell itself was not worshipped, but rather regarded as an attribute of some goddess. It was due probably to this fact that the cowry was known to the ancients under the appellation of "Concha Venerea,"—the shell of Venus.[45] As pointed out by Dr. J. C. Melvill,[46] the generic name of

between the Lower and Upper Palæolithic. The Lower Palæolithic, he suggests, may be known as the Palæanthropic, the Upper as the commencement of the Neoanthropic, Age. (See "The American Museum Journal," vol. xvi., May, 1916, p. 325.)

[44] Abstract of paper on "The Commencement of the Neolithic Phase of Culture," read before the Manchester Literary and Philosophical Society, April 4th, 1916.

[45] As well as the goddess of love, the word Venus signifies the highest throw of the dice. (Horace, 'Carmina,' 2, 7, 25.) It is not surprising, therefore, that we find the cowry—the shell of Venus, used in so many games of chance.

[46] "Survey of Genus Cypræa," *op. cit.*, p. 184.

this group of shells, '"Cypræa, or more classically Cypria, is derived from one of the many attributes of Aphrodité, owing, doubtless, to her worship not only having been inaugurated, but for long years principally centralized, in Cyprus, then a luxuriant and smiling island, teeming with industrial wealth. Horace[47] addresses her as 'Diva potens Cypri,' and Tibullus,[48] when apostrophizing the goddess, thus : 'Et faveas conchâ, Cypria, vecta tuâ.'"

As previously remarked, cowries were worn as amulets by the women of Pompeii in order to prevent sterility. The presence of these shells in women's-graves in France and the South of England seems to point to the prevalence of the same ideas in the Middle Ages.

In the 18th century the custom of wearing a large cowry as an amulet or charm was prevalent among Kendure Tartar women and girls.[49] And in the neighbourhood of Naples, cowries, it is stated, are still worn by the poorer class.[50] Money-cowries are used by the Bedouin women of the Hadramaut, South Arabia, to adorn their girdles ;[51] also by the women of the races of the Volga region, as breast and forehead ornaments by the Tshuwash and Mordvins, and as necklaces by the Tsheremis. They are also to be seen on the necks of the Kirghis women, and on the curious head-dresses of the Bashkir women ;[52] and

[47] Horace, Od., 1, 3, 1.

[48] Tibullus, III., 3, 4.

[49] G. A. Cooke, "System of Universal Geography," vol. i. (1801), p. 448.

[50] Faussett, "Inventorium Sepulchrale," 1856, p. 68.

[51] Schneider, *op. cit.*, p. 117 ; Strabo, bk. xvi., ch. iv., par. 17 (Bohn's Ed., vol. iii., p. 202), speaking of the Troglodytæ of the Arabian Gulf says : "The women carefully paint themselves with antimony. They wear about their necks shells, as a protection against fascination by witchcraft."

[52] Schneider, *op. cit.*, p. 117 : Ratzel, "History of Mankind," iii., p. 327, gives a figure of one of these Bashkir head-dresses ornamented with small cowries.

in England they are occasionally noticed worn in long strings by travelling gypsies.

According to Professor Ridgeway,[53] cowries are still used, combined with a Christian medal, in Corfu as a child's amulet; and also in Montenegro.

In the following pages frequent references will be found to the use of cowry-shells as amulets of magical import in Africa, Asia, Pacific Islands, and elsewhere.

The custom of decorating the trappings of horses with cowries, doubtless with the object of averting the evil eye, is found in Persia as well as in India (where elephants carry such ornament), in Hungary and in Norway. And according to Ridgeway (*op. cit.*, p. 248), Mr. F. W. Hasluck, when travelling in the Morea in 1907, saw a boar's tusk charm on a horse in Triphylia, with a pendant of a cross formed of four cowries sewn on leather.

Lane, in his "Modern Egyptians,"[54] informs us that cowries are still used by the people of Egypt, and are regarded as a protection against the evil eye. With this object they are often attached to the trappings of camels, horses, and other animals, as well as to the caps of children. Pickering[55] remarks that on ascending the Nile to Kenneh, the modern capital of the Thebaid, about 30 miles below the site of ancient Thebes, cowries were seen used as money by market women of the Ethiopian [? Soudanese] race. Culin, in his "Chess and Playing Cards,"[56] reports that in the streets of "Cairo" at the Columbian Exposition was a family of Bishareen from the Eastern desert, near Assouan,

[53] W. Ridgeway, "The Origin of the Turkish Crescent," *Journ. Roy. Anthro. Inst., G. B. and I.*, vol. 38 (1908), p. 248, pl. 21, fig. 23.

[54] E. W. Lane, "Modern Egyptians," vol. i., 1849, p. 343.

[55] Pickering, "Races of Man" (Bohn's Ed.), 1863, as quoted by Stearns, "Ethno-conchology," *Rept. U.S. Nat. Mus.*, 1887, (1889), p. 303.

[56] Stewart Culin, "Chess and Playing Cards," *Rept. U.S. Nat. Mus.*, 1896, (1898), p. 815 footnote.

whose headman practised soothsaying with cowries. He threw several cowry-shells, and made his prediction from the manner in which they fell.

At Sennaar, in the Soudan, cowry-ornament still obtains to-day among the Hassanieh Arabs. Caillarud, in the 20th year of last century, saw cowries ornamenting the fringed girdle of the young girls in Sennaar. According to Carl Ritter, they are still found as trimmings for women's girdles in Abyssinia ;[57] and Haldeman[58] describes a curious Abyssinian necklace composed of European beads, cowry-shells, bits of brass, copper coins, etc.

According to Schneider (*op. cit.*, p. 173). a large leather object from Somaliland, richly ornamented with cowries, is in the Dresden Museum,[59] and a similar object, ornamented in the same way, was brought from Somaliland by Riebeck in 1883. That the cowry was in use here in early times is proved by the discovery of *Cypræa annulus*, along with glass, enamel, stone and other objects, in the ruins of Bender Abbas, near Berbera. The age of these ruins is still problematic ; they may belong to "Persian times."[60] Presumably this refers to the period of the Persian conquest of Egypt in the sixth century B.C.

In the Upper Nile region cowries, rubbed down on their backs, are used by many negro peoples. The Lango, Latuka, Lur, Shuli and Nuer have very many cowry-ornaments, more especially on their head-coverings. According to Ratzel (*op. cit.*, iii., p. 30), the head-coverings of the Shuli and Lango "consist of strong bass-matting, close set with concentric rows of cowries, with a woven blunt appendage, shaped either like a flat conical cup or like a

[57] Schneider, *op. cit.*, p. 173.

[58] S. S. Haldeman, "United States Geographical Surveys West of the 100th Meridian," vol. vii., Archæology, 1879, p. 263.

[59] See also Ratzel, *op. cit.*, II., fig. 14 of plate facing p. 533.

[60] Schneider, *op. cit.*, p. 118.

helmet enclosing the head and hanging down the back of the neck" (see also Ratzel, *op. cit.*, i., p. 101). Among the Latukas and their kinsfolk heavy wicker helmets, with crests recalling Greek forms, are used; these are ornamented with a ring of cowries all round (Ratzel, III., p. 30, and p. 41, fig. 7). Among the Djibba tribe of the Sobat country, one of the Nile tributaries, *cowries appear to be associated with head-hunting, as among the Nagas of Assam (infra*, p. 50*). Like these latter people, the Djibba warriors wear the hair taken from the decapitated heads of slain enemies, in addition to wearing goat-skin dresses, ivory armlets and belts of cowries.*[61] *By the Jurs, beads and cowry-shells are considered as essential at betrothals.*[62]

In East Africa rubbed-down cowries[63] are used largely by the Akikuyu, Kavirondo, Akamba and Masai peoples. Kavirondo men are noted for their peculiar and elaborate head-dresses made of these shells. Among the Akamba, Masai and other tribes, cowries appear to be associated with unmarried girls (as among the Chettis of Southern India, *infra* p. 48). The young unmarried girls of the Akamba tribe wear belts and aprons adorned with beads and cowries; but these ornaments are discarded after the birth of the first child. The Masai women also wear a peculiar head-band covered with cowries during the period of "engagement."[64] The Lumbwa girls' aprons, too, are similarly adorned, doubtless with the same significance.[65] Ridgeway, in his paper on "The Origin of

[61] Brown, "Races of Mankind," III., p. 16.

[62] Schneider, *op. cit.*, p. 173.

[63] On the East side of Africa, the ring-cowry (*C. annulus*) appears to be the form universally used.

[64] "Women of all Nations," pp. 266 and 268.

[65] Specimens in the Manchester Museum; see also *Journ. Anthrop. Inst.*, vol. 33 (1903), pl. xxix., for illustration of a Lumbwa girl wearing one of these cowry-ornamented aprons.

the Turkish Crescent" (*op. cit.*, p. 253, pl. 25), figures and describes two curious head-dresses worn by the Ja-luo of Kavirondo, one consisting of ram's horns and cowries, the other of reed-buck's horns and cowries. These remind us, Ridgeway remarks, of the combination of boars' tusks and cowries in Greece (*supra* p. 18). Captain R. F. Burton gives us an interesting account of the cowry-trade of the regions north of the 'Land of the Moon,' in his description of "The Lake Regions of Central Equatorial Africa."[66] The cowries, he reports, are collected from various places between Ras Hafun and Mozambique, the trade being in the hands of Moslem hucksters. They are purchased on the mainland by a curious specimen of the 'round-trade'; money is not taken, so the article is sold measure for measure of holcus grain. From Zanzibar the use of cowries spreads in two directions; one to the regions north of the 'Land of the Moon' where they form the currency, though they are also occasionally in demand as an ornament in Unyamwesi;[67] the other to the West African coast. That the collecting of cowries on the East African coast dates from ancient times is evident from the list of articles of export at Rhapta in the first century A.D. Among the articles mentioned in the "Periplus"[68] as exported from this place—the Quiloa or Kilwa of modern times—is an item, Νάυπλιος ὀλίγος (*lit.* little sea-shell), a term which has given rise to some discussion. Vincent[69] says: "It seems to be an inferior tortoise-shell from the context" (which he translates, "tortoise-shell of superior kind, but not equal to the Indian; and a small

[66] *Journ. Roy. Geog. Soc. Lond.*, vol. 29, 1859, p. 448.

[67] See Ratzel, *op. cit.*, II., plate facing p. 533, fig. 1, for cowry ornamented head-dress of Wanyamwesi.

[68] Vincent, "The Commerce and Navigation of the Ancients in the Indian Ocean," London, 1807, vol. ii., p. 172.

[69] *Ibid.*, p. 748.

quantity of that species called nauplius.") "It may, however, be a different commodity." As cowries are an article of commerce on this coast to-day, the suggestion naturally presents itself of interpreting the term as a reference to shells (? cowries) intended for ornament.

In Uganda, cowries have been a recognised form of currency from an early date. According to the Rev. John Roscoe,[70] the standard of currency among the Baganda was set by the value of the cow. During the reign of Suna, he tells us, a cow was sold for 2,500 cowry-shells; a goat for 500; a fowl for 25; a large cock for 50; and an ivory tusk weighing sixty-two pounds was valued at 1,000 cowry-shells[71]. Cooking-pots were priced according to size; a large pot was sold for 200 cowries, small ones for 20 or 30 cowries. A milk-pot cost 60 or even 100 cowries; a tobacco pipe from 5 to 10 shells; and a water-pot from 40 to 50 shells.[72] "Before the introduction of cowry-shells," Roscoe informs us, "a blue bead (nsinda) was used; this was very rough and badly made, but it was considered to be of great value; one bead was of equal value with one hundred cowry-shells. Still earlier, before the introduction of the bead, a small ivory disc was used, known as *sanga*; one of these discs was valued at one hundred cowry-shells. When the cowry-shell was first introduced, which was probably in the reign of King Semakokiro, two cowry-shells would purchase a woman."[73] By these same people cowry-shells have also been used from the first in religious and other ceremonies. One of the many interesting uses, mentioned by Roscoe, is their employment in the decoration of an amulet called *Luzalo*, which partakes of the nature of a fetish,

[70] Roscoe, "The Baganda," London, 1911.
[71] *Ibid.*, p. 456.
[72] *Ibid.*, p. 455.
[73] *Ibid.*, p. 457.

and is designed to insure fecundity. This consists of a piece of wood sewn into a small cat-skin bag ornamented with cowry-shells, which is worn round the waist, so that the amulet rests in front of the wearer.[74] Divination is also practised by means of pieces of leather decorated with cowry-shells. They are also offered to propitiate the spirits of trees ; and sent by the king as presents to each of the important deities. Another most important use is to decorate the jawbones of deceased kings. Some five months after the death and burial of a king the tomb is entered and the head severed from the body and brought away. The jawbone is then removed and placed in an ant hill until all the flesh is eaten away, the skull meanwhile being given special burial in a place near the tomb. The jawbone, after being cleansed and washed in beer and milk, is wrapped in fine barkcloth which has been rubbed with butter, and is decorated with beads and cowry-shells collected during the king's lifetime from people succeeding to chieftainships. A temple is then built to receive the decorated jawbone and umbilical cord of the late king, and also the umbilical cord of the ex-queen.[75] At the end of the royal mourning cowry-shells are thrown on the fire as if they were fuel ; this is also done at ceremonies to prolong the king's life.[76]

In the marriage ceremonies of the Baganda these shells form an important part of the dowry, the bridegroom having to provide as many as two thousand five hundred.[77] On the birth of twins it is the custom for the grandmother to make each twin a present of cowry-shells, and everyone coming to see them throws cowry-shells into a basket

[74] *Ibid.*, p. 331.

[75] *Ibid.*, pp. 109-10.

[76] *Ibid.*, p. 108.

[77] *Ibid.*, pp. 88-9.

placed to receive these offerings.[78] On the death of a twin the body is embalmed and the ghost is caught by the medicine man and made up into a "twin" (mulongo). To do this, the man goes by night into a space in front of the the house, spreads a barkcloth on the ground, kills a white fowl, cuts out its tongue, and places it on the barkcloth; he then watches for the first insect that alights on the barkcloth, catches it, and wraps it up with the fowl's tongue, saying that the ghost has come back again. The insect and fowl's tongue are then made up into a "twin" decorated with cowry-shells and beads, put into a wooden pot and preserved.[79]

In addition to the above uses, cowries are employed by the Baganda to decorate the royal drum. Drum-sticks made from human arm-bones are also ornamented with them, as well as the stool of the war-god Kibuka.[80]

According to Stuhlmann, cowries were used in Karagwe, on the west side of Victoria Nyanza, to ornament the leather-cuff which serves as a protection of the left wrist at archery, and in Unyora, north-west of the above lake, the most important personage wears, as token of his rank, a strip of cow-hide adorned with cowries and coloured glass beads. The Wassongona and Wahuma have cowries as neck-ornaments, and the young girls of the latter wear a hip-cord of cowry-shells and beads, which are sewn on leather strips.[81]

According to Schweinfurth the Madi and Niam Niam wear cowry-ornaments, but they do not appear to be of great importance among the latter people. Cowries were much sought after in former times by the Bongo, but they have long since fallen out of the category of objects

[78] *Ibid.*, p. 71.
[79] *Ibid.*, p. 124.
[80] *Ibid.*, pp. 26, 214 and 306, fig. 49.
[81] Schneider, *op. cit.*, p. 172.

of value.[82] Schweinfurth also depicts a fashion in hair among the Monbuttus, by which the head is surrounded with a regular saint's halo. The hair, in plaits, is spread out round the whole head and fastened to a hoop adorned with cowry-shells.[83]

The Wavira of the upper Ituri wear in their ears a wooden plug with cowries at both ends ; this object is in the Lunda Empire an amulet hung by a string from the neck.[84] Cowries were also seen by Junker used as ornaments by the Bagarambo on the Welle River. And Thonner reports cowries in common use by the Mogwandi north of the upper Dua and by the neighbouring races ; by the Mobali in the hair, and by a Banza man from Bogola as a neck-chain. On the middle and upper Ubangi and on the Welle to its source cowries pass current as money ; they are also in use as such by the Basoko inhabiting the region of the Congo between Stanley Falls and the Aruwimi confluence. In 1886 Lenz saw them used for ornament by the Nkaia at Riba Riba above the Stanley Falls, as well as in other places. According to Johnston cowries were made use of as small-change everywhere on the Upper Congo. Large numbers of them were placed in the graves with the dead. In Nyangwe they were in use along with other objects of barter in Livingstone's (1871), Cameron's (1874), Stanley's (1876) and Pogge's time, and often served as presents for the chiefs and for purchasing necessary articles of food in the districts through which these and other travellers passed. In Uhombo, between the Congo and Lake Tanganyika, they were the current money in Stanley's time. At Mpala,

[82] *Ibid.*, p. 173 ; and Schweinfurth, " The Heart of Africa," London, 1873, vol. i., p. 299 ; ii., p. 9.

[83] Ratzel, *op. cit.*, iii., p. 69 ; Schweinfurth, *op. cit.*, ii., p. 7 (Text-figure).

[84] Ratzel. *op. cit.*, iii., p. 69.

on the western shore of Lake Tanganyika, they were seen by Richard as head-ornaments or sewn on straps ; he also observed them in use by the Nollo Nollo, living north thereof, to ornament the forehead, neck and wrist ; in the latter case, two shells were worn attached to the middle of a thin strap, probably an amulet of some kind. Among the Warua of the Upper Congo similar ornaments were noticed.[85]

On the middle Congo cowries are a recognised currency about Lukolela, Ngowe, Matumba Lake, etc., being used by the Balolo people. On the Mongalla, Thonner, in 1896, found cowries the necessary legal tender for continuing his journey up the river and for the purchase of food-stuffs. Wissmann, Wolf, and other travellers found them highly estimated in the Kassai-Sankuru basin. According to Wolf, in 1885, these shells together with a black and white striped glass bead were used as barter-material by the Baluba people of this region.[86]

In the Lunda Empire, the wooden plug set with cowries at both ends, which the Wavira wear in their ears, is hung by a string from the neck as an amulet.[87]

According to Magyar, cloth in Kimbundaland, about 1850, was reckoned at from 25 to 50 cowries, or busio-shells, per ell or yard, according to the distance from the coast ; and this same observer tells us that the women of the Mondumbe, inwards from Benguela, ornament their hair with small white cowries (*C. moneta ? Oliva ?*).[88]

In describing the Ovambo, Ratzel (*op. cit., II.*, p. 541) informs us that they barter ivory for beads, iron, copper, shells, and cowries, with the Portuguese-speaking black traders on the further side of the Cunene River. Such

[85] Schneider, *op. cit.*, various pages.
[86] *Ibid.*
[87] Ratzel, *op. cit.*, iii., p. 69.
[88] Schneider, *op. cit.*, pp. 159 and 172.

articles as they obtain in this way, and do not themselves need, they trade away to the south and east. On another page (p. 553) of the same volume, he gives an illustration (after Serpa Pinto) of Kimbande-Ganguellas with cowry-ornament. It is of interest to note that the shells (*C. moneta* or *annulus*), are employed by the women and girls as a decoration in connection with their curious method of hair-dressing; the man shown in the illustration has no such ornament. According to the observation of Waitz, cowries were usual as ornament among Hottentots and Kaffirs.[89] Unfortunately no indication is given as to whether these were the small white money cowries, or some other. From Ratzel's figure (II., p. 268) of a Bushman amulet, consisting of large cowries attached to a sort of belt, it would appear that cowries other than those so universally employed for currency are used also in the south. It is impossible to define the species from the illustration, but it appears to be a large spotted one, probably *C. tigris*, whose nearest habitat is off the East African coast, in the neighbourhood of Zanzibar.

Returning north, to the French Congo, we find that, according to Foret[90] the races on the Tem and on the Ivindo use cowries as ornaments. Lenz, in 1876, found them so employed in the hinterland of Gaboon. Kund also reports cowry-ornaments for the neck among the Bateke, not far from Leopoldville. Dennett[91] figures a Bavili "guardian fetish," called Mpembe, consisting of a wooden image in the shape of a man, the eyes of which are cowry-shells with the apertures outwards. Ratzel

[89] Schneider, *op. cit.*, p. 172: According to Peringuey (*Ann. S. Afr. Mus.*, viii, 1911, p. 104), Sparrman mentions and figures Hottentot ornaments of marine shells (*Nerita albicilla* ?) and a leather head-dress adorned with three spaced rows of "cowries."

[90] Le Mouvement Géographique, 1902, No. 9 (*fide* Schneider).

[91] R. E. Dennett, "At the Back of the Black Man's Mind," London, 1906, p. 91, pl. 5.

(*op. cit.*, iii., p. 83, fig. i.), also gives an illustration of a Beneki fetish with cowry-eyes, which has a strong resemblance to the Bavili example.

In the Cameroon district the use of cowries as currency seems to have ceased, but the shells are applied as ornament. Zintgraff writes that in Adamawa and the frontier-land such was the case. The Bali warriors were allowed to carry a bandolier upon which the cowries were sewn in two rows, the channelled opening of the shell being to the outside. They were also seen arranged in cross-form on a small, flat, cloth packet, which was worn on a string from the neck, resembling the amulet which the Mahommedan wears. Another interesting use noted by Zintgraff is that by the chief of the Bafut, living on the Adamawa frontier, who had utilized cowries as a sort of mosaic on the floor of his spacious palm-wine hall.[92] The shells are also worked into the coiffure of the women in the Cameroons, as many as two hundred being required.[93]

We now reach the chief zone of circulation of the cowry—the western Sudan and Guinea coast. For many centuries the shells have passed as a means of currency throughout the greater part of this region, and in many places they have also played an important part in religious and other ceremonies.

Our earliest knowledge of their employment in this region as currency dates from the 14th century, when the Arab traveller Ibn Batūta saw them in use for transacting business at Kawkaw (Gao or Gagho) on the Niger.[94] Cadamosto, who visited Cape Verde in 1455, also noted the white shells, "porcellete or cowries," used in exchange

[92] Schneider, *op. cit.*, p. 171.

[93] Joyce and others, "Women of all Nations," p. 351.

[94] "The Travels of Ibn Batūta," translated by the Rev. Samuel Lee, London, 1829, p. 241.

between the Arabs and the natives of the interior.[95] Leo Africanus,[96] who wrote at the beginning of the 16th century, mentions in his description of Timbuctoo that "the natives of this place use small mussel-shells or snail-shells, which were brought from Persia, of which 400 equal one ducat, and six and two-thirds go to a Roman ounce." In Benin, at the end of the 15th century, according to Pereira, cowries, under the name Iguru, were in currency. In the description of Commodore Stewart's embassy journey to Mekines (Mequinez) in 1721, it is stated:[97] "The goods, which they (the Moroccans) convey to Guinea, are salt, cowries, etc.—Cowries are small shells, which are brought from the East Indies, and they are current instead of ready money, and as such have the highest value."

From Timbuctoo and the Upper Niger[98] the territory of the cowry-currency extends to Lake Chad, with wide spaces here and there in which the cowries do not, or only in a minor degree, pass as currency. Barth mentions three such places within the great bend of the Niger,—Aribinda, where the shells had no value, and Isaye (Ise) and Bambara, where they were employed only in the sale of milk. The places noted by Barth as having the cowry-currency were Kabara, near Timbuctoo, Saraiyamo, Kubo, Dore, Bundore, Sinder and Say on the Niger; Gando, Sokoto, Wurno, Bamurna, Badarana, Kammane, Bunka, Katsena, Kano, Lamisso, Kukameirua and Gummel, all in the northern part of Sokoto State; Tasawa, immediately north of the Haussa region; as well as Zinder, Wushek,

[95] Deniker, "Les Races et les Peuples de la Terre," Paris, 1900, p. 324; Schneider, *op. cit.*, p. 119.

[96] Leo Africanus, "Description de l'Afrique," Lyon, 1556, p. 225 (*fide* Schneider, *op. cit.*, p. 119).

[97] Thos. Winterbottom, "Nachrichten von der Sierra-Leone-Küste," p. 221 (*fide* Schneider, *op. cit.*, p. 119).

[98] Segu, Jenné, Kaarla, etc.

Muniyo, and Kuka in Bornu. In the Haussa States, Clapperton, in 1826, found the shells in general use as money, and his companion, Richard Lander, mentions cowry-currency in Kano, Womba, Catup, Kazigee and Ragada in S.W. Haussa district. Rohlfs, on his 1867 journey from Kuka through Gujeba and the southern Sokoto beyond Yakoba to the Benue, and down this river to its junction with the Niger, and then up to the Rabba, finally passing through Ilorin and Yoruba to the coast at Lagos, moved throughout in the region of the cowry-currency. In the district of the Marghi, cowries did not circulate as money in Barth's time, yet he managed to obtain two fowls with them, owing to the fact that the shells were desired as ornament by the "young ladies."

In the 17th and 18th centuries cowries were used very largely by the slave-traders of the Guinea coast from Senegal southwards; but in later times, English gold and the American dollar, together with other articles of exchange, displaced the shells to a very great extent. Where not actually in use as money, they still continue to be employed for ornamental and other purposes.

The territory of cowry-ornament in Western Africa is of much wider extent than that of the cowry-currency. In Morocco, for example, Lenz saw cowries as ornament on the daughter of a chieftain. Such ornament is also said to be used by the Tuarag of the southern Sahara, and, according to Nachtigal, by the women in Tibesti. The Joloff women string them on their hip-girdle. Clapperton saw cowries frequently on the fringes of the goat- and sheep-skins wound round the hips of the women of "Kufu," and at Wazo he saw them on the collars of greyhounds. According to Staudinger the Fulbes had their numerous hair-plaits frequently decorated with cowries. In Loko, Gurich, in 1885, found children

hung with cowry-shells. The men-folk of the pagan Kado negro in southern Haussa-Land, wear, according to Rohlfs, a skin-apron hung with cowries, and the young girls of the Kedje negro fasten on their leather-girdles a bundle of small shells presented to them by their bride-grooms. Barth mentions shell-ornament as in use by the young women and girls of the Marghi, and in Bagirmi, by the pagan population in the south. The women especially wear such ornament of cowries, and caps too are made thereof, with which to decorate the heads of deceased relations. Nachtigal also states that in this neighbour-hood, at the funeral of a chief, "a small gourd-shell full of beads and cowries was placed on the mouth in order to serve to some extent as travelling expenses." According to Rohlfs, the Mahommedan Aulâd Rashîd (Arabs in N.W. Darfur) decorate the hair-plaits of their camels and horses with the porcelain-shells, and the women of Pebu adorn their arms with them. According to Nachtigal, the wood- or tin-trombone, about one and a half metres long, the hollowed antelope-horn, and the short pipes of wood, brass or horn, which emitted such terrible tones at festive processions of the Sheikhs in Bornu, were all adorned with numerous cowries on the surface. The Kawembu in Kanem and the Buduma of the islands of Lake Chad also wear neck-chains of cowries. The shells are a market-article in Kuka. They are taken as an article of barter in journeys from Kuka to Bagirmi and Wadai, where, especially by the native Arab and also by the pagan negro, they are used as ornament. The Mahommedan women in Bagirmi wear cowry neck-chains; the wives of the pagans in the Mofu district wear the shells on the girdle and apron strings. In Abeshr (Wadai), at the wedding of the king's daughter, thirty large baskets, adorned with shells or beads, were carried

in front. Being wishful to journey through the pagan-land of Runga, Nachtigal provided himself with cowries. In Darfur he saw no more cowry-ornament.[99] In Haussaland Robinson informs us: "The most common form of gambling is a game called by the natives *chacha*. It consists in throwing up five cowry-shells, the player winning or losing according as the shells fall, the right or the wrong way up."[100]

Regarding the use of cowries in the region of the northern Guinea coast we have ample material to draw upon in the accounts of numerous observers. In Sierra Leone, at the time of Thomas Winterbottom, three or four necklaces of cowries were worn at the mourning for a wife, and the husband of the deceased woman was also required to wear a necklet of shells. According to Major R. G. Berry[101] the shells are used to play a game called jagay, or knuckle-bones. They also form part of the sacred contents of the medicine bag, or Borfimor, used at the initiation ceremonies in connection with the Human Leopard Society of the Sierra Leone cannibals. A Borfimor bag obtained by Major Berry was found to contain four smaller bags, one of which held two tau-shaped iron crosses, the stems of which were lapped with cotton, and to the top of each was tied a cowry-shell, or sign of life. "The tau cross, or *crux ansata*," Berry remarks —and in quoting this passage I do not accept all of the statements—" was the emblem of Osiris, and is called the Sign of Life, the symbol of resuscitation and new birth, expressive of the idea entertained by the Egyptians and

[99] Schneider, *op. cit.*, various pages (quoting Nachtigal, Barth, and others).

[100] C. H. Robinson, "Haussaland," London, 1896, p. 206.

[101] R. G. Berry, "The Sierra Leone Cannibals, with Notes on their History, Religion, and Customs." *Proc. Roy. Irish Academy*, vol. xxx., Sect. C., No. 2, May, 1912, pp. 45, 53, and 67.

other philosophers, that nothing created was annihilated, and that to cease to be was only to assume another form, dissolution being merely the passage to reproduction. In its association with the Borfimor [*and in this connection the presence of the cowry must not be overlooked*],[102] we seem to have the reflection of some such ideas, the fetish being animated by the indwelling life of the victim and the spirit attracted to it." (p. 67).

The Borfimor bag also contained a pebble made of some earthy matter and lime, in one side of which was incorporated a cowry-shell.

The remarkable resemblance in the use of the money-cowry here to that of the Ojibwa and Menomini tribes of North America, who also employ the same shell, has been pointed out already in an earlier paper.[103]

In Liberia, according to Stewart Culin,[104] pierced cowry-shells (*i.e.*, rubbed down on the back) are used in fortune-telling. (*See Fig.* 1, *E*). Ratzel (*op. cit.*, III., page 105) also gives a figure (f. 6) of a sword-sheath from Liberia which is ornamented with cowries arranged in stars.

Bowdich, who in 1817 was sent on a mission of peace from Cape Coast Castle to Kumassi, mentions that in Accra, as in Gaman, Kong and other neighbouring places, cowries had currency.

North of Ashanti proper, in Koranza and Atabuobo, Perregaux found them in full use and of higher value than on the coast. According to this observer, in Koranza, they were counted per thousand, and 100 cowries were

[102] The italicized sentence is my own. J. W. J.

[103] J. W. Jackson, "The Money Cowry (*Cypræa moneta*, L.) as a Sacred Object among North American Indians," *Manch. Memoirs* (*Lit. and Phil. Soc.*), vol. lx. (1916), No. 4.

[104] Culin, "Chess and Playing Cards," *op. cit.*, p. 815, footnote, and fig. 134 on p. 817.

Fig. 1.

A.—*Cypræa annulus* (after Stearns).
B.—*Cypræa moneta* (,, ,,).
C.—*C. moneta* var. *atava* Rochbr. (after Roberts in Tryon).
D.—*C. moneta* var. *atava* Rochbr., used by Ojibwa Indians (after Hoffman).
E.—Cowries (*C. moneta* v. *atava* and v. *ethnographica*) used in fortune-telling, Liberia, Africa (after Culin).

worth 3d. In Okwaon, on the contrary, they were reckoned thus :—

35 cowries = 1 string (Obang).
12 × 35 „ therefore 12 strings = 3d.
50 × 35 „ „ 50 „ (1750 cowries) = 1 Head (Atramatiri).

In the plural, Atiri, was used for 2-9, and Atramatiri, for 10 or more heads. A game with cowries (obviously the same game as elsewhere in this region) was named Atramaton, *i.e.* to throw cowries. These words are combinations with the word Atrama, which denotes cowries. "They were so named," says Perregaux, "in the Tshi language in Aquapim and Ashanti, while in Okwaon and the northern lands the designation Serewa was used. A single cowry was called Niwa, because of its likeness to an eye[105] (Oniwa), and ten cowries were called Niwandu."[106]

Among the Mamprusi of the Gambaga country, north of Ashanti, cowries, together with kola nut, figure among the objects distributed to guests and musicians at wedding ceremonies.[107]

Apart from their use as currency, cowries play a very important role as amulets and in fetish-worship among the Ewe negroes of Togo district. They are worn on the neck, arm, wrist and ankle, and regarded as amulets against wounds and sickness, and for luck in hunting. Mischlich records that the hunt-fetishes, Gbofu of Dadease and Nakuku of Mjooti, both in Adeli, a district in the hill-country of Togo, were ornamented with cowries. Spiess mentions that they were worn in quantity by expectant women, to ward off danger. It was the custom among the

[105] The likeness of the aperture of the cowry to the closed eye may explain why these shells have been applied as eyes for fetishes, etc., in the Congo region, Borneo, New Zealand, etc.

[106] *Fide* Schneider, *op. cit.*, pp. 144-5.

[107] "Women of all Nations," p. 344.

Ewe that if a woman died in childbirth she was not given the usual burial treatment, and was not buried in her hut. The same shells are also employed as eyes in the Begbowo idol, as an ornament of the fetish-priests and priestesses at their dance, as offerings to the protective deity and at ordeals, at which it depends upon whether the priest, who has taken two or three cowries in the mouth, retains them there or casts them out.[108] *The similarity of these customs to those current in other parts of the world is remarkable. As will be seen in the subsequent account, the association of the cowry-shell with pregnancy is to be found in places so far away as India and Japan; while the spitting out of cowries appears to be identical with the medicine ceremonial of the Ojibwa and Menomini Indians of North America.*

According to Klose, Togo warriors wear caps ornamented with cowries. As a protection from evil small children have a pair of consecrated cowries interwoven in the hair, while the women of the bush-people of the hinterland fasten cowries as a fetish on the side of the head. Hunters, too, ornament therewith the butt-end of their flint-lock guns, in order to ensure success, and on a much honoured hunt-fetish in the neighbourhood of Soluga lay buffalo- and antelope-horns adorned with cowries. At the entrance to villages frequently stand clay-idols with cowry-eyes and shell-ornament, and in front of them lay abundant offerings of old spirit-flasks and calabashes filled with cowries. At ordeals for the detection of a murderer, the priests blow poison towards the sun out of a cowry-decorated pipe, which, when the suspicion is correct, falls down as blood, while at the trial of a thief two pieces of wood, adorned with a cowry at each end and wrapped round with a long cord, are made use of.[109]

[108] Schneider, *op. cit.*, pp. 169-170 (quoting Mischlich and Spiess).

[109] Schneider, *op. cit.*, p. 170 (quoting Klose, "Togo.")

In Togo-land cowries are also paid by the relations of a girl seeking admission among the Ewe-priestesses, and when the betrothed Ewe-youth brings his wife home he pays to her parents 4 marks in cowries.[110] At death ceremonies, relations, friends and acquaintances, place quantities of cowries in the grave with the dead, in order that the deceased may purchase food and palm-wine, and reward the old ferry-man Akotia who carries him in his canoe over the wide river Assisa to the region of the dead. According to Monrad,[111] the negroes fully believe that everything expended in the funeral obsequies, such as the goods, coral, cowry-money, etc., placed in the grave, the tobacco used and the wine drunk on such occasions, will be of use to the defunct when he rises up in the future world.

Among the Bassari-people Klose found the previously-mentioned game of chance (cowry-throwing), at which he saw soldiers wager cowries to the value of from 1 to 3 marks at a cast. Cowry-casting for divination was also employed by the priests in the fetish-village Dadease.

According to R. Fr. Müller, at the circumcision of boys the circumciser receives a cowry, conveys it to the forehead of the person about to be circumcised, and finally buries it with the prepuce in a small pit; as a reward he receives 81 cowries. According to the same informer, cowries were offered to the small-pox fetish.[112]

That cowry-money has circulated in Togo for ages is proved by an old saying, handed down from generation to generation among the Ewe-negroes, according to which cowries were found in a basket despatched from heaven

[110] Herold, "Mitteil. aus den deutsch. Schutzgebeiten," Pd V. (1892), p. 151 (*fide* Schneider).

[111] Monrad, "Gemälde der Küste von Guinea," p. 11 (*fide* Schneider).

[112] Müller, "Fetischistisches aus Atakpama (Deutsch-Togo)," *Globus*, 1902, No. 18, pp. 280-1 (*fide* Schneider).

by Mawu (God), which the black eagerly appropriated for purposes of trade.[113]

In Dahomey similar customs to those of the Ewe-negroes prevail. The famous Amazons of the king, who dwell in a house richly ornamented with skulls and cowry-garlands, have a custom of glueing a cowry-shell for each slain enemy to the stocks of their muskets, the shells being glued by means of the blood of the slain man. Another custom of the Dahomeyans takes the form of a "fight for cowries" thrown by the king and his Amazons, this being followed by the sacrifice of a human victim upon which cowries and other objects have been dashed. At the conclusion of these ceremonies a number of cowries are thrown upon the blood-stained earth.[114]

In Yoruba, as in Dahomey, cowries have been a recognised form of currency for centuries, and in recent years thousands of tons have been imported into Lagos. According to Hoffmann, in 1850, about 40 white cowries (*C. moneta*) were equal to an English penny. In Yoemba, in Lander's time, it was the custom on the death of a chief for one of his wives to destroy all his possessions and shell-money and then destroy herself. On his travels through Yoruba Lander also saw a sorcerer whose cowry-hangings he estimated at 20,000 specimens. Not far off the river Mussa, Forscher saw a hut with a veiled entrance in which it was customary for passing negroes to place cowries, because the god housed therein gave them water, corn, and yams in abundance.[115]

Among the Egbas, according to Brown,[116] it is the custom when a great man dies for slaves to be slain to act as his attendants in the land of spirits. Messengers

[113] C. Spiess, *Deutsch. Geogr. Blätter*, 1899, p. 33 (*fide* Schneider).
[114] Brown, "Races of Mankind," vol. iii., N.D., pp. 92 and 100-2.
[115] Schneider, *op. cit.*, pp. 154-6, and 170.
[116] Brown, *op. cit.*, III., pp. 114-15.

are also despatched to the dead in the same way. Slaves or prisoners taken in war are richly dressed and laden with cowries, and when they become intoxicated by rum they are slain. In this manner it is believed that not only messages, but the circulating medium with which the victims are laden, can be conveyed to the departed relatives of the people who have performed this pious sacrifice. With these people sixteen appears to be a sacred and mystical number. Thus, for instance, when meditating war the war priest throws into the air sixteen cowries. Much depends upon the way these fall. Those which fall with the aperture upwards portend peace; but if a greater number fall with their apertures downwards, then the divination is considered to be favourable to war.

Some interesting details of the use of the cowry as a medium for the transmission of messages are given by the Rev. C. A. Gollmer in his paper on "African Symbolic Messages."[117] In the Yoruba country, he informs us, the natives send messages to each other by means of shells, feathers, corn, stone, coal, etc., through which they convey their ideas, feelings, and wishes, good or bad. Cowry-shells in the symbolic language are used to convey, by their number and the way in which they are strung, a variety of ideas. Thus one cowry, strung on a short bit of grass fibre, or cord, may indicate "defiance and failure"; two cowries, if strung face to face, "relationship and meeting," but if strung back to back, "separation and enmity"; two cowries and a feather, "speedy meeting"; three cowries, with their faces all looking one way, strung with an alligator pepper, "deceit"; six cowries may indicate "attachment and affection."

According to Bloxam,[118] cowries are similarly em-

[117] *Journ. Anthrop. Inst. Gt. Bn. and I.*, vol. xiv., p. 169.

[118] *Ibid.*, vol. xvi., p. 295.

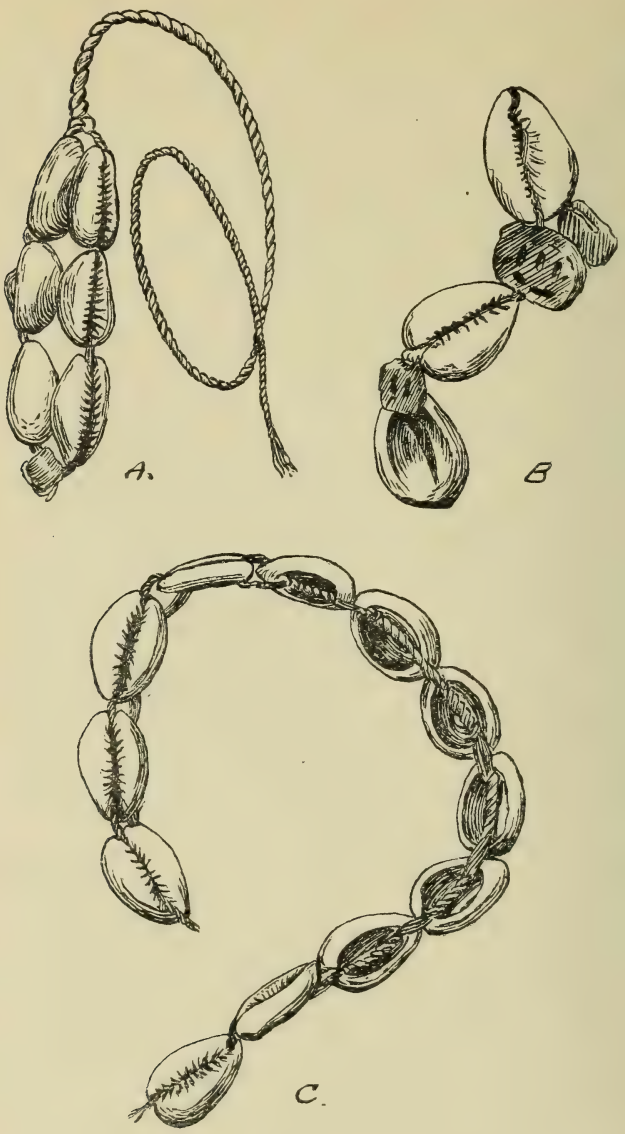


Fig. 2.

A.—West African symbolic message (after Bloxam).

B.—"Amulet for protection," from Kafr Ammar, Egypt (after Petrie).

C.—String of *C. annulus* from rubbish dating to xxii. dynasty. Medum (in Manchester Museum).

ployed by the Jebu tribe of the west coast. The shells are strung together in varying numbers, odd numbers, as a rule, being of evil import, while even numbers express good will. A single cowry may be sent as an unfavourable answer to a request or message. In some cases other substances besides cowries are included in the aroko or symbolic letters. Thus we find pieces of spice, a piece of mat, and a feather, introduced for the purpose of conveying some significant idea. (See *Fig.* 2 *A*).

This method of employing cowries for the purpose of conveying certain ideas is of interest in connection with discoveries made in Egypt of knotted cords with the same cowries, papyrus charm pendants, uzat eyes, etc., attached. Several of these cords are figured by Petrie[119] in his book on "Amulets," all from Kafr Ammar, xxiii-xxvth dynasty. He places the objects among amulets for protection and says no explanation of their meaning is known in Egypt. (See *Fig.* 2 *B*.)

The history of the cowry in Africa may be concluded with a few remarks on its use in Benin and about the lower Niger. Dennett, speaking of the customs of the Bini,[120] informs us that "the people swear by licking and touching stones, iron, cowries, bits of twisted rope, and the crushed leaves of a plant, asking these things to kill them if they are not telling the truth." According to the same authority, every great house has an altar to Olukun—the river spirit of Olukun or Great Benin river—in or near to which is a pot of water, cowries (Igo) and a heap of other objects. At Ewesi, not far from the Sobo plains, is a temple to Olukun, in which are very old wooden figures (like those into which nails are driven in the Congo) covered with cowries and other objects. In front of the

[119] W. M. Flinders Petrie, "Amulets," London, 1914, p. 29, No. 131, pl. xvii.—xix.

[120] R. E. Dennett, *op. cit.*, p. 193.

great figure of Olukun himself sits a priest, half hidden by long strings of cowries hung from the roof. At Igo, a town on the Gilly Gilly road, there is a mound on which is an altar to Olukun with chalk cones and cowries on it, all covered by a shed. The presence of an Odigi, or sacred well, is generally made known along the roads by a tree and a mound of earth and cowries.[121] The shells are also scattered at certain death ceremonies.[122] Their association with marriage is seen by the fact that among the upper class cowries, together with kola-nuts and palm-wine, are given as presents on betrothal. "Often on the roads one passes a small tree planted by the side of the road, near which are chalk marks and a mound of earth, cowries, yams and plantains. This tree has been planted in memory of the fact that some woman or other has brought forth a child on that spot."[123]

On the Bonny river, at Ibo on the Niger, and in other places of the Niger-delta, cowries have, or had until quite recently, general currency. In this neighbourhood also it is the custom, at the interment of a chief, to bury all his treasure with him in the grave. The brothers Lander narrate that when they visited Idda, on the left bank of the Niger, much consternation and indignation prevailed, owing to the fact that the new chief had again exhumed and misappropriated for his own use the treasure of cowries which had been buried with his father.[124]

In India the money-cowry seems to have been regarded with special favour for amuletic and currency purposes from very early times. It has been met with on several pre-historic sites accompanied with bangles made from the sacred chank shell, *Turbinella pyrum*, and

[121] *Ibid.*, pp. 222-4, and 227.
[122] *Ibid.*, p. 207.
[123] *Ibid.*, pp. 198-9.
[124] Schneider, *op. cit.*, pp. 156-7.

other shell ornaments. Its association with chank bangles is specially interesting and seems to imply a similar cultural source for the use of these white shells. Hornell in his work on "The Sacred Chank of India"[125] informs us (p. 50) that fragments of *Cypræa moneta* and of a *Nerita*, also beads of entire *Paludina* shells, were found near Hampasagra, on the Tungabhadra, 53 miles west of Bellary, along with 18 fragments of chank bangles, Mr. Bruce Foote placing the age of this find as late neolithic or early iron age. Also (p. 51), "from made ground in the north bank of a nullah, at Huvina, near Hadagalli, 65 miles west of Bellary, came a single bangle fragment with two money cowries (*Cypræa moneta*)," and "from an old site north of Bellaguppa, came a fragment of a working section of chank shell, an entire *Cypræa moneta*, four fragments of scraper made of *Unio* shell, and three fragments of chank bangles; associated with these were a neolithic celt, a fragment of a corn-crusher, some pottery, and two metal fragments, one being possibly part of a bronze ring." A further discovery of the money-cowry is recorded from Damnagar, Amreli Prant, Kathiawar, where two examples were found associated with a great number of fragmentary chank bangles, a basalt corncrusher, a bloodstone hammer, and chert and agate cores (Hornell, p. 57). The example of *C. moneta* figured by Hornell on plate V. (3456-13) is of great interest from the fact that the back of the specimen has been rubbed down in the characteristic Ancient Egyptian and East African fashion.

In dealing with the money of India prior to Alexander the Great, Del Mar (*op. cit.*) states that: "In Bengal the principal money finds have been of cowries, the metallic monies being comparatively few" (p. 66). And

[125] Madras Fisheries Bulletin, No. 7, 1914.

again (p. 90) in speaking of the standard of money in India from Alexander the Great to the Mahommedan Conquest, he says: "In Northern India the copper pieces were supplemented by gold and silver multipliers, in Southern India by dividers of cowrie-shells." In the Manikyala tope in the Punjab, opened in 1830, "were found mingled together cowrie shells, gold coins of the Kadphises and Kanerkes, Roman consular coins shortly before the Christian era, and copper coins of the Sassanian line."[126] Cowries formed the bulk of the currency between the beginning of the Christian era and the Mahommedan dynasty of A.D. 1203.[127] In Bengal the system of a copper standard with cowry dividers and gold and silver multipliers remained unchanged after the Mahommedan Conquest. Ibn Batūta, the Arabian traveller of the 14th century, gives an account of the collection of the cowry-shells in the Maldive islands, from whence they were exported to Bengal in exchange for rice. He states that a *bustus* equalled a *lak* of cowries, and four *laks*, or four *bustus*, were estimated as worth one gold *dinar*, but the rate of exchange was so variable that occasionally a *dinar* would purchase as many as twelve *laks* of cowries.[128]

In Orissa, the next kingdom south of Bengal, accounts were kept in cowries, and the following scale of values prevailed during the early part of the Mahommedan rule: 4 cowries = 1 gunda; 5 gundas = 1 boory; 4 boories = 1 pun; 16—20 puns = 1 khawun; 10 khawuns = 1 rupee. In 1740, a rupee exchanged for 2,400 cowries; in 1756, for

[126] Marsden, "Numismata Orientalia," edited by Edward Thomas, London, 1874, quoted by Del Mar, *op. cit.*, p. 86 footnote.

[127] Marsden, *op. cit.*, p. 37; Del Mar, *op. cit.*, p. 90 footnote.

[128] Del Mar, *op. cit.*, p. 99; Edward Thomas, "The Chronicles of the Pathán Kings of Delhi," London, 1871, p. 110 footnote. In Lee's translation of "Ibn Batūta" (London, 1829, pp. 179 & 181) the cowry (Wada) is referred to as alms-gifts and as currency in the Maldives.

2,560 cowries; in 1833, 6,400 cowries; and in 1845, 6,500 cowries. Major Rennell, who was in Silhet in 1767-8, speaking of the cowry-money, remarks: "I found no other currency of any kind in the country; and upon an occasion, when an increase in the revenue of the province was enforced, several boat loads (not less than 50 tons each) were collected and sent down the Burrampooter to Dacca." As late as 1801 the revenues of the British district of Silhet "were collected in cowries, which was also the general medium of all pecuniary transactions, and a considerable expense was then incurred by Government in effecting their conversion into bullion." (Thomas, *op. cit.*, pp. 110—111 footnotes.)

Lovell Reeve, in his "Conchologia Systematica,"[129] mentions that "a gentleman residing some time since at Cuttack is said to have paid for the erection of his bungalow entirely in these cowries [*C. moneta*]. The building cost him about 4,000 rupees sicca (£400 sterling); and as sixty-four of these shells are equivalent in value to one 'pice,' and sixty-four pice to a rupee sicca, he paid for it with above sixteen millions of these shells."

In the Deccan, up to the thirteenth century, but few coins of any kind seem to have been minted, the currency appearing to consist almost entirely of cowries (Del Mar, *op. cit.*, p. 108).

In early times, cowries, it is thought, were brought to India from the Philippines and Borneo, as well as from the island of Bima near Macassar (Celebes); in later times they were obtained from the Laccadive and Maldive Islands. Of the latter, the Arab Masudi, in the first half of the 10th century, remarked that the queen had no other kind of money than the cowries, which were

[129] Reeve, "Conchologia Systematica," London, 1842, vol. ii., p. 262 footnote.

obtained by means of rafts made of the branches and leaves of the cocoa-nut lashed together and floated on the surface of the sea. The work was carried out by women. When sufficient animals had become attached to the rafts by climbing aloft among the branches, these were dragged ashore and the shells spread out on the sands to enable the sun to dry up the contained animals. The Arab author, Ebn Beithar, who died in 1248, also mentions the Maldives as a locality from which cowries were obtained.[130] These islands are also referred to by Ibn Batūta, the Arabian traveller of the 14th century, who speaks of the use of cowries (Wada) there as currency and alms-gifts.[131] At the beginning of the 17th century, François Pyrard de Laval, observed the fishing of the cowries by the women of the Maldives. According to him they were collected twice a month, three days after the new moon and three days after the full moon. The shells were in such demand in India that sometimes 30 to 40 ships were seen loaded with them. In Cambay and other Indian places, the prettiest were used as ornaments along with silver and gold, and held as great rarities, as if they were precious stones. They also passed current there as money under the name Boly, and at burials they were scattered on the way from the house of the defunct to the cemetery as alms for the poor.[132] Captain Owen, in 1832,[133] gives an account of the collecting of cowries in the Maldives somewhat similar to that of Masudi. He further remarks on the similarity of the rafts, or balsas, to those used on the coasts of Chili and Peru.

Bengal seems to have been the great market for the cowries from the Maldives. From there they were widely

[130] *Fide* Schneider, *op. cit.*, p. 110.
[131] See Translation by Lee, *op. cit.*, pp. 178 & 181.
[132] Schneider, *op. cit.*, p. 111.
[133] *Journ. Roy. Geog. Soc. Lond.*, vol. 2, 1832, pp. 82-3.

distributed over India, not only over the plains of the north and north-west, but also along the east coast and even to the slopes of the Himalayas and to the Deccan plateau.[134]

Besides their use as money in India the same shells are employed to ornament the trappings of horses and elephants, as previously remarked. They are also strung like beads or sewed like buttons on the dresses of the Brinjari women of Nagpur province.[135] According to Dr. Curt Boeck, they are traded in Indian bazaars, especially for bordering the cloth-masks of shamans.[136] In many Indian places, *e.g.*, Gahsi, Punjab, one still finds *C. annulus* worn by the native women. The Todas of the Nilgiri Hills, S. India, wear a *C. moneta* on a heavy silver collar (Schneider, *op. cit.*, p. 117). According to Thurston, this same species is also worn by Toda women on their thread and silver armlets and necklets. As in Africa, cowries are associated with Toda death ceremonies. When a person dies, various objects such as rice, honey, and other food-stuffs, together with cowries, "with which to purchase food in the celestial bazár," are burned with him. Like the Todas, the Kotas of the Nilgiris occasionally make use of cowries; they are sometimes seen on the necklets of the women; and at funeral ceremonies when the skulls of the deceased are brought to the funeral ground to be burnt, a pole, twenty feet long, decorated with cowries, is also burned in the case of a male. The Nilgiri Irula women, too, sometimes have bead necklets with cowry-shells pendent.[137]

[134] Schneider, *op. cit.*, p. 111.

[135] Stearns, "Ethno-conchology— A Study of Primitive Money," *Report U. S. Nat. Mus.*, 1887, p. 302.

[136] Schneider, *op. cit.*, pp. 116-7.

[137] E. Thurston, Madras Government Museum, Bulletin No. 4, 1896, pp. 154, 174 (Todas), 192, 198 (Kotas); Vol. ii., No. 1., 1897, pp. 14 and 16, pl. v. (Irulas).

Thurston[138] also cites a curious custom among the Chettis (traders) of Southern India of unmarried girls wearing a necklace of the money-cowry and beads, it being "unusual for unmarried girls to wear any badge of their condition." This association of cowries with the unmarried is of great interest in view of a somewhat similar custom in East Africa, to which reference is made on another page. Thurston further states that "when a Hasalara or Hasala (forest tribe) of Mysore dies, somebody's evil spirit is credited with the mishap, and an astrologer is consulted to ascertain its identity. He throws cowry (*Cypræa moneta*) shells or rice for divination, and mentions the name of some neighbour as the owner of the devil. Thereupon the spirit of the dead is redeemed by the heir or relative by means of a pig, fowl, or other guerdon." (Thurston, *op. cit.*, pp. 164-5.)

Turning to Ceylon we find that Hildburgh, in his "Notes on Sinhalese Magic,"[139] states that cowries are worn as amulets by infants. This same writer also gives illustrations (pl. XI.) of masks worn by devil-dancers in which sometimes the upper, or both upper and lower, teeth are formed of cowry-shells. Culin, in his "Chess and Playing-Cards,"[140] describes a cowry game, Kawadi Kelia, in which cowries of different kinds are used as men, each player also having three cowries as dice. This game is clearly related to the Hindu game of Pachisi, also played with cowries. The shells are thrown as dice and the counts are according as the apertures fall uppermost or not. "The game of Pachisi," says Culin, "may be

[138] E. Thurston, "Ethnographic Notes in Southern India," Madras, 1906, p. 68; In his article on "Some Marriage Customs in Southern India" (*Madras Govt. Mus. Bulletin*, vol. iv., No. 3, 1903, p. 155) Thurston gives the species as *Cypræa arabica*.

[139] *Journ. R. Anthrop. Inst.*, vol 38 (1908), p. 193.

[140] *Report U. S. Nat. Mus.*, for 1896 (1898), pp. 851-4.

regarded as an expansion and elaboration of the type of game represented by the Korean *Nyout*, and sacred and divinatory in its origin." *Nyout* is played with staves. "The two faces of the staves, black and white, may be regarded as signifying the dual principles of nature, masculine and feminine. A feminine significance is widely attributed to the aperture of the cowrie shell. Its convex side would naturally be regarded as masculine; hence its substitution for the staves would seem to have been an easy transition."

Games like Pachisi, in which cowries are used as dice, are known in the Maldive Islands under the name *Dhola*, and in Syria under the name of *Edris a Jin*; also in Burma as *Pasit*.[141]

In parts of Further India the cowry is still in circulation as money. In Siam and Laos it serves as a form of currency, and in the former country 6,400 cowries are said to equal about 1s. 6d.[142] At the end of the 17th century La Loubère found it in use in all Siam; it was obtained from the Laccadives, from Borneo and the Philippines, where it was taken in as ballast by the ships. About the middle of the 18th century, according to Gervaise, the Siamese small-change consisted of small shells, which the Europeans called cowries and the Siamese Bia. According to Hertz they were no longer in use as small-change at Bangkok in 1881.[143]

In Burma the women of the Taungthas wear a loose skirt adorned with a wide belt of cowries or silver filigree work.[144]

[141] Culin, *op. cit.*, pp. 856-7.

[142] Deniker, *op. cit.*, p. 324: See also "Century Dictionary," ii., p. 1321.

[143] Schneider, *op. cit.*, pp. 107-8.

[144] "Women of all Nations," p. 574.

In Thibet, according to Carl Ritter, cowries serve as ornaments for women's girdles.[145]

Among the Khasias, a stone-using tribe inhabiting the Khasia Hills of Eastern Bengal, cowries are associated with marriage. According to Brown,[146] "the marriage ceremony is of the most primitive type. All that is necessary is for the couple to sit together on one seat and receive their friends, to whom they give a marriage feast. A union so easily contracted is just as easily dissolved. The woman receives five cowries which she throws away; they are then free to be married again, the children remaining with the mother."

Among the Nagas of Assam, head-hunting was formerly a qualification for matrimony, and a warrior, having slain an enemy, had the privilege of wearing a kilt decorated with cowry-shells, collars ornamented with similar shells, tufts of goat hair dyed red, and locks of hair from the heads of the persons killed.[147]

A similar custom is prevalent among the head-hunting Patasiwa of Seran, where a warrior is not allowed to take a wife until he can show the head of an enemy he has slain. In proof of his prowess the warrior wears as many little white shells (? cowries) round his neck and arms as he has murdered men.[148] An even more striking identity in the association of cowries with head-hunting is to be found in East Central Africa, where the Djibba tribe wear not only the cowries but also the hair from the heads of the slain enemies (see p. 20).

[145] Schneider, *op. cit.*, p. 117.

[146] Brown, *op. cit.*, III., p. 302; quoting Lieut. Steel, R.A., *Journ. Ethnol. Soc.*, VII., p. 305. By some philologists the Khasias are considered to be Thibetans.

[147] "Women of all Nations," edited by Joyce and Thomas, 1909. p. 581.

[148] G. A. Cooke, "System of Universal Geography," vol. i. (1801), p. 609.

Among the Dyaks of Borneo it is the custom to place the small white money-cowries in the eye-sockets of the skulls of enemies, which they keep.[149] The baskets of the Dyak head-hunter are also decorated with the same cowries.[150] Specimens in the Leiden Museum show *C. annulus* as decoration for sword-hangings from West Borneo, and *C. moneta* as decoration for a betel-pouch from South-east Borneo.[151]

In certain parts of Malaysia, cowries are attached to the fishing-nets, not as "net-sinkers" as recorded by several ethnologists,[152] but in order to ensure success in fishing or to ward off evil influences. In Nias, an island off the west coast of Sumatra, *Cypræa vitellus* is so used; in Engano, an island in the same neighbourhood, the species is *C. ventriculus*; in Timor, *C. arabica*; while off N.W. New Guinea the shells employed are *C. moneta*, *C. caput-serpentis*, *C. erosa*, *C. lynx*, *C. tigris* and *C. vitellus*.[153]

According to Von Martens, the Berlin Museum contains specimens of clothing ornamented with cowries, from Bali, near Java.[154] In Timorlaut the natives adorn cloth-girdles with cowries, and in the same island, four species of cowries, *C. annulus*, *C. isabella*, *C. erosa*, and *C. helvola*, are employed as neck-ornaments.[155]

Van der Sande,[156] describes and figures several neck-ornaments from Dutch New Guinea, on which specimens

149 Stearns, *op. cit.*, p. 302; Ratzel, *op. cit.*, i., p. 135 (fig.).

150 Ratzel, *op. cit.*, vol. i., p. 448 (fig.)

151 Schmeltz, "Schnecken und Muscheln in leben der völker Indonesians und Oceaniens," Leiden, 1894.

152 The slight weight of these shells would render them valueless as sinkers.

153 Schmeltz, *op. cit.*,

154 Schneider, *op. cit.*, p. 118.

155 *Ibid.*, and Schmeltz, *op. cit.*

156 Van der Sande, "Nova Guinea," iii, 1907, pp. 83, 117-8, pl. xiii., f. 4.

of *C. annulus* are strung on strips of Pandanus leaf, the whole hanging down from a neck string in front of the chest. Schmeltz (*op. cit.*, pp. 23 et seq.), also cites the use of *C. argus* and *C. lynx* as breast-ornaments, and *C. moneta* on hip-strings in N.E. New Guinea; *C. moneta* on arm band, *C. annulus* as leg- and shield-ornaments in S.E. New Guinea; and *C. moneta* as ankle-ornament in N.W. New Guinea.

In the Philippines, according to Schmeltz (*op. cit.*), *C. annulus* is used as a neck-ornament, as decoration for the coat-of-mail of the Moro, and as the eyes of ancestor-images.

According to Pickering the cowry was formerly in use as money in the Hawaiian Islands. He says[157]: "An estimable and intelligent Hawaiian lady gave me the following particulars respecting former customs: . . . Money was certainly known, for with a string of cowries (*Cypræa moneta*) it was possible to buy any article wanted. Specimens of the same shell that were finer than usual, having a high polish and deep yellow colour, were extravagantly valued, and could only be worn by the highest chiefs, who also exclusively possessed wooden calabashes." In the Vancouver collection, British Museum, are Leis of *Cypræa moneta* from these islands.[158]

In Oahu, Hawaii Islands, a large cowry, *Cypræa mauritiana*, is attached to fishing-nets in order to ensure success. Specimens of this are in the R. D. Darbishire collection, Manchester Museum. The stone (lava) "net-sinkers" of Oahu are curiously enough all modelled after this shell, being roughly carved with a high round back and flat base, with a groove for the attachment of a cord.

[157] Pickering, "Races of Man" (Bohn's Ed.), 1863, quoted by Stearns, *op. cit.*, p. 303.

[158] "Bernice Panahi Bishop Museum," Honolulu (1898-1902), Report i., p. 43.

Cypræa moneta appears to have been current also in other islands of the Pacific, as Brenchley states:[159] "At Eramango [New Hebrides] a shell called 'Nunpuri,' the *Cypræa moneta*, passes as money, as also in New Caledonia."

In the Bismark Archipelago, says Schneider (*op. cit.*, p. 118), *C. annulus* was found as money in special cases.

In Gilbert Archipelago, the Ellice and Kingsmill Islands, *Cypræa moneta* and *C. annulus* are used as body-ornament and for decorating implements and tools.[160]

F. W. Christian, in his article "On Micronesian Weapons, Dress, Implements, etc,"[161] figures a cowry-shell used in the Carolines for stripping off the outer skin of the bread-fruit. The figured shell looks like a *Cypræa mauritiana*. He also figures an *Ovulum ovum* shell (often alluded to as the white cowry) pierced for ornamenting prows of canoes. The use of this shell as a canoe-ornament is general throughout the Pacific. Amongst other places it is recorded from the Pelew Islands, Yap, Gilbert Archipelago, Samoa, Niné, Viti Islands, Solomon Archipelago and Torres Straits Islands. In some of these and in other islands it is also worn as an ornament for the neck, breast, or leg, and placed on the outsides of native houses. In Tonga it is used as a grave-ornament, and in the Solomons as decoration of an idol.[162]

In Tahiti, *Cypræa moneta* and *C. talpa* are worn on the neck, and *C. tigris* occurs on the base of an idol from Tahiti, now in the British Museum.[163] Sir C. H. Read, in his description of specimens obtained on Vancouver's

[159] Brenchley, "Cruise of the 'Curaçoa,'" 1873, p. 299, quoted by C. Hedley, *Mem. Aust. Mus.*, iii., pt. 7, 1899, p. 452.

[160] Schneider, *op. cit.*, p. 118.

[161] *J. Anthrop. Inst*, 28 (1898-9), pp. 288 et seq., pl. xxiv., f. 5.

[162] Schmeltz, "Schnecken und Muscheln in leben der völker Indonesiens und Oceaniens," Leiden, 1894.

[163] *Ibid.*

voyage, figures an instrument of palm-wood, used for splitting bread-fruit in this island, to which are attached two tiger cowries with their inner whorls broken out, and one end cut off.[164]

In the Loyalty Islands, the orange cowry (*Cypræa aurora*) is greatly appreciated. The Rev. Mr. Hadfield, in the course of his missionary work, came across a fine specimen in a native hut in Lifu, where it was held in much veneration by the occupant, who considered it a kind of fetish.[165] Mr. Hadfield also gives us some further interesting information regarding this species. He tells us that his wife came upon a specimen which, according to the native report, had been found by an old woman who was struck on the forehead by a demon, who asked her why she took the shell. The woman, it is said, died from the effects of the blow.[166] This fine shell is used as a badge of high rank in Tonga, or Friendly Islands, as well as in Fiji. One of the most remarkable Fijian industries is the working of whales' teeth to represent this cowry, as well as the commoner *C. talpa*, which is more easily imitated.[167]

The New Zealanders, it is stated, use *Cypræa asellus* and other shells to form the eyes of their idols.[168]

Codrington, in his "Melanesians" (Oxford, 1891, p. 26), tells us that in Aurora, the nearest of the New Hebrides to the Bank's Islands, the natives have a story that the first woman came from a cowry-shell. Somewhat analogous ideas are expressed in the traditions of the Samoans as to the origin of man. By these people it is believed

[164] *J. Anthrop. Inst.*, 21 (1891-2), pp. 105-6, pl. x., f. 5.

[165] Melvill & Standen, "Lifu Mollusca," *Journ. of Conchology*, viii., 1895, p. 112.

[166] *Ibid.*, p. 131.

[167] A. H. Cooke, "Mollusks," Camb, Nat. Hist., 1895, p. 98.

[168] *Ibid*, p. 99.

that man is formed from a species of mussel and that gods are present in some of the shell-fish.[169] A similar idea concerning the possibility of human beings living in shells is current among the Indians of the N.W. coast of America. According to the Haida and Kaigani the first people sprang from a cockle-shell.[170]

In the Far East, cowries, both large and small, were used as a medium of currency long before the Christian era. Frequent allusions are made to them in ancient Chinese literature, but the authenticity of some of these records and of the dates assigned to the period when cowries were in use is open to some criticism. M. Terrien de Lacouperie[171] has presented us with some remarkable views on the origin of Chinese civilization, based upon the study of numerous Chinese works, and from his statements it would appear that cowries were used as money in China as early as 2,000 years B.C. But the fact that many of the works which he studied are, to a large extent, based upon tradition renders them unreliable as evidence as to date. It seems certain, however, that cowries were in circulation among the people of Eastern China in the seventh century B.C., and the southern country of Ts'u figures largely in connection with supplies of these shells for currency. Contact with the west through sea-traders of the Indian Ocean (Erythræan Sea), who are claimed to have established a colony in the Gulf of Kiao-chou (South Shantung) in 675-670 B.C., had made them familiar with many western practices, and it is not improbable that the use of the cowry was one of them. Some time about 600 B.C., the king of Ts'u issued two

[169] Turner, "Samoa, etc." London, 1884, pp. 8, 12 and 17.

[170] Niblack, "The Coast Indians of Southern Alaska and Northern British Columbia," *Rept. U.S. Nat. Mus.*, 1887-8 (1890), p. 378.

[171] Terrien de Lacouperie, "Western Origin of the Early Chinese Civilisation from 2,300 B.C. to 200 A.D." London, 1894.

sizes of small coins, bean-shaped (in the fashion of the Æginætan and Lydian coins of 750-700 B.C.) and inscribed with their respective weights. These coins are known in native numismatics as metallic cowries, *Ho-pei tsien*, because their shape suggested that of the once useful little shells they superseded. They have also received other quaint appellatives, as 'Ghost-heads,' *Kwei-tou*; 'Ghost-faces,' *Kwei-lien*; and 'Ants'-noses money,' *Y-pi tsien*.[172] The introduction of this and other metallic currencies caused the circulation of cowries to disappear gradually in eastern China, and in B.C. 221, the king of Ts'in, having assumed the title of She Hwang-ti, "the first universal Emperor," issued an order forbidding henceforth the use of gems, pearls, tortoise-shells, cowries and tin for currency purposes. Cowries, however, still continued to be regarded as objects of appreciation; and in B.C. 179 we find the king of Nan-yueh sending as presents to the Chinese emperors 500 purple cowries[173] along with other gifts. At the end of the First Han dynasty an attempt was made by Sin Wang Mang, the usurper (A.D. 9-22), to revive the circulation of cowries and tortoise-shells, but little success rewarded his efforts. According to Lacouperie,[174] the cowry currency consisted of five sorts, regulated as follows:—

"(1) The great shells; 4 *tsun* or inches, 8 *fen* or 10ths in length; two of which formed a *pang* or pair; value 216 cowries.

(2) The bull shells; 3 *tsun*, 6 *fen* in length; a pair of which was worth 150 cowries.

[172] Lacouperie, *op. cit.*, p. 118; also "Catalogue of Chinese Coins in British Museum." London, 1892; and "The Metallic Cowries of Ancient China, 600 B.C.," *Journ. Roy. Asiatic Soc.*, xx., 1888, pp. 428-439.

[173] The money cowry, *C. moneta*, before becoming fully adult, has a deep purple back, and probably these were the objects sent.

[174] Lacouperie, *op. cit.*, 1892, p. 382.

(3) The small shells ; 2 *tsun*, 4 *fen* in length ; a pair of which was worth 30 cowries.

(4) The lesser shells ; 1 *tsun*, 2 *fen* in length ; a pair of which was worth 10 cowries.

(5) The smallest shells (*cypreæ monetæ*, or cowries), being smaller than 1 *tsun* 2 *fen*, were not fastened in pairs ; each was worth three *cash*. Those which were smaller than six *fen* were not used for currency."

The shells of groups 1 to 4 seem to have been undoubted cowries, as in group 5, only larger, as the same characteristic Chinese hieroglyph denoting cowry (see *Fig.* 3 *C.*) appears against each of the groups.

Unfortunately, except for dimensions, the particulars are lacking as to the species of cowries forming these four groups.

If we may take the measurements as more or less approximating to English inches, it is possible to find a series of cowries inhabiting Eastern seas which would come within these dimensions. For example, *Cypræa testudinaria* (the "tortoise-cowry," named by Linnæus from its resemblance to the tortoise) might very well have served for group 1. Of the others, group 2 may have been smaller examples of the same, or even *Cypræa tigris* ; group 3 may have been *Cypræa lynx* ; while group 4 were probably exceptionally large examples of *Cypræa moneta*. The average length of the latter species is about one inch.

Regarding the tortoise-shells re-issued by Wang Mang, Lacouperie informs us that "there were four different sorts, of various sizes and denominations, with different values, but the details have not yet been handed down to our time." It is not a little curious that the larger cowry-shells were also of four different sorts, sizes, and values.

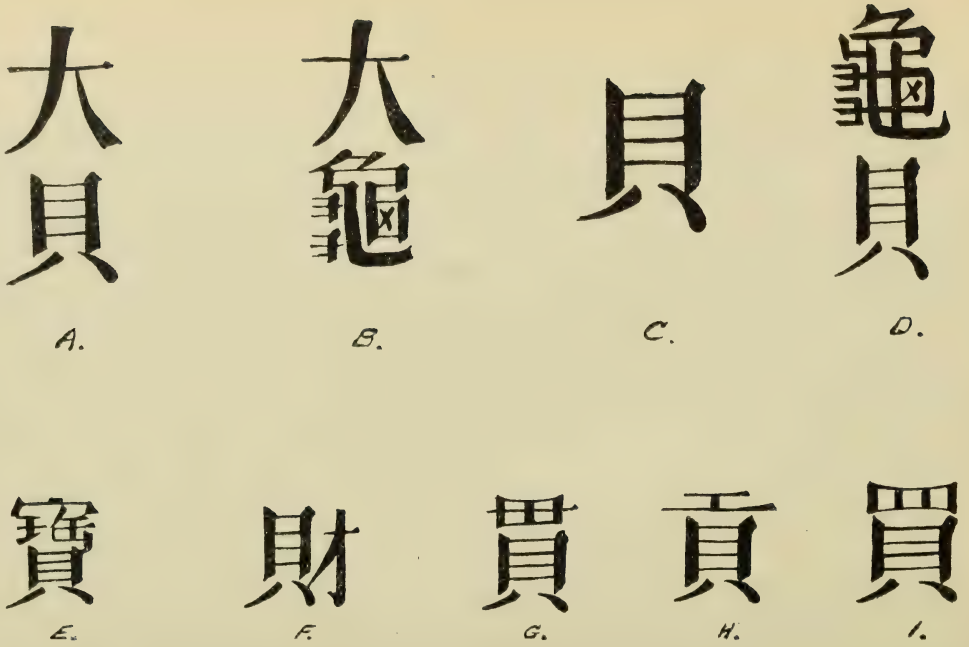


Fig. 3.

Chinese hieroglyphs for Cowry and Tortoise.

A.—"Great tortoise-shell," according to Legge ("Shoo King," v., xxii., 19); "Great Shells" (=cowries) of Wang Mang currency (after Lacouperie).
B.—"Great tortoise," according to Legge ("Shoo King," iii., i., 52).
C.—"Cowry" (after De Groot). *D.*—"Tortoise-shell" (after Morrison).
E.—Precious. *F.*—Wealth. *G.*—Strings of Currency. *H.*—Tribute. *I.*—To buy (*E* to *I*, after De Groot).

This suggests the possibility of the so-called "tortoise-shells" being really cowries.

From the following facts it is obvious that some confusion has taken place with regard to the interpretation of certain symbols in ancient Chinese works.

In Dr. Morrison's "Dictionary of the Chinese Language"[175] a symbol known as *pei* (see *Fig.* 3*C*), is translated (p. 622, No. 8471) as "the tortoise shell or pearl-oyster shell": on an earlier page (p. 510, No. 6811) quite a distinct symbol, *kwei,* is translated "tortoise," and the *pei* symbol is attached to denote "tortoise shell"—*kwei pei* (see *Fig.* 3*D*).

In a Chinese work, the "*Li Ki*," or "Treatises on Ceremonial Uses" (referred to on a later page) the *pei* symbol (*Fig.* 3*C*) is used to denote a particular object placed in the mouth of the dead. The symbol in this case has been correctly interpreted by the translator of the work as meaning "cowry."

In the "Shoo King" (v., xxii., 19), the same symbols (*Fig.* 3*A*) as quoted by Lacouperie for the "great shells" (*i.e.*, cowries) of the Wang Mang currency, are used in a paragraph describing a display of various precious relics. But these characters have been translated by Dr. Legge, in his "Chinese Classics,"[176] as the "great tortoise-shell."

The "Tribute of Yu" ("Shoo King," iii., i., 52) refers to a particular object presented to Yü from the country of the nine Këang, the symbol denoting this object being the *Kwei* (No. 6811, p. 510) of Morrison's Dictionary (*Fig.* 3*B*). It is here translated by Legge as "the great tortoise."[177] In his footnotes to this passage the translator states that "according to the 'Historical Records' the

[175] Dr. R. Morrison, "Dictionary of the Chinese Language," 1819, vol. i., pt. ii.

[176] Dr. J. Legge, "Chinese Classics," 1865, vol. iii., pt. ii., p. 554.

[177] *Ibid.*, vol. iii., pt. i., p. 116.

great tortoise attained the size of two cubits and a half. Such a creature would be esteemed very valuable, where divination was much relied on"; and further, according to Gan-Kwŏ, that "the tortoise was not a regular article of tribute, but was presented when required by express command."

In the "Pwan-Kang" ("Shoo King," iv., vii., 14), the characteristic symbol, *pei* (*Fig.* 3*C*) occurs in a passage dealing with the hoarding propensities of government officials, and is here translated by Legge as "cowries."[178]

From the above remarks it will be seen that the *pei* symbol has been incorrectly interpreted in certain cases.

Some interesting particulars concerning the use of cowries in connection with the dead are given by Dr. J. J. M. de Groot, in his work on "The Religious System in China."[179] The ancient Chinese, he tells us, used several precious articles for preserving their dead. To this end they availed themselves of cowry-shells, which were so valuable in ancient times for currency. This fact, well known to Sinologists, is especially manifest in the ancient hieroglyph denoting the cowry (see *Fig.* 3*C*), which enters into the composition of most characters signifying things of value and acts connected with trade and barter (see *Fig.* 3, *E*, *F*, *G*, *H*, *I*).

These shells were used in association with rice for stuffing the mouth of the dead. They were made to support the last molar tooth on the left and the right side, and the mouth was finally filled up with rice.

According to the "*Li Ki*," or "Treatises on Ceremonial Usages" (an important source of our knowledge of China during pre-Christian times), the mouth of the Son of Heaven was stuffed with nine cowries, that of a

[178] *Ibid.*, iii., pt. i., p. 240.

[179] Vol. i., bk. i., "Disposal of the Dead." Leyden, 1892, pp. 275-6.

feudal lord with seven, that of a great officer with five, and that of an ordinary official with three.[180]

In some of the out-of-the-way corners of China cowries remained in circulation for many centuries. In Marco Polo's time (A.D. 1271—91) cowries, called "porcellani" by this traveller, were still in use in the country of Yunnan, the shells being gathered at the group of islands now known as Pulo Condore, off Cochin China.[181]

In the 16th century the cowry-currency seems to have been officially suspended in Yunnan province. At the present time cowries appear to have completely lost their money value in Yunnan, since Lieutenant Garmer found them nowhere in use north of Luang Prabang, Laos; and in western Yunnan they were worn only as ornament by the Kakhyens. Carl Bock likewise saw cowries on the head-masks of the leaders of the mule-caravans which come from Yunnan into northern Further India.[182]

It is doubtful whether the cowry was used as currency in Japan, though it is possible that in olden times shells from the neighbouring Liu Kiu Islands were so used. The Japanese name, *Takara* (=prosperity, riches), *kai* or *gai* (=shell), may indicate their use as money. In Kampfer's "Description of Japan" (London, 1727, Bk. i., ch. ii.) appears: "Takara gai, called Kauri in India, brought from the Maldives and other islands and imported into Bengal, Pegu and Siam, where it serves as current money." K. Florenz reports that the Japanese women at their confinement hold in the hand a "Koyasu-gai (Easy-delivery-shell), a species of cowry," in order to ensure certain and easy delivery, a practise analagous to

[180] *Fide* De Groot, *op. cit.*, p. 275.

[181] Colonel Henry Yule, "The Book of Ser Marco Polo," London, 1871, vol. ii., pp. 39 *et seq.*

[182] Schneider, *op. cit.*, p. 107.

that of other peoples, *e.g.*, the Indian.[183] Attention has already been called to the similarity of this custom to that of the Togo people of West Africa.

The money-cowry (*Cypræa moneta*) is, and has been for centuries, a sacred object among the Ojibwa and Menomini Indians of North America, and is employed in initiation ceremonies of the Grand Medicine Society.[184]

The use of this particular cowry by these Indians is of peculiar interest; in the first place, owing to it being *alien to the American continent*, and in the second place, in view of its intimate association with so many remarkable and fantastic beliefs and practices in different parts of the Old World.

The tradition among the Indians is that the original sacred shell—*mī'gis*,[185] of the Ojibwa; *konä'pamik*, of the Menomini—was introduced by a particular hero-god, who acted as an intermediary between the Great Unknown and the Indians, and founded their Medicine Society. Among the Menomini the sacred shell appears always to be the small white money-cowry, *Cypræa moneta*,[186] but among the Ojibwa, according to Hoffman, it consists of a small white shell, of almost any species: but the one believed to resemble the mythical *mī'gis* is similar to the money-cowry. This fact would seem to imply that the money-cowry is scarce among them, and those they possess, doubtless handed down from generation to generation, are regarded with special veneration as being like

[183] Schneider, *op. cit.*, p. 108.

[184] W. J. Hoffman, *Bureau of Ethnology* (United States), 7th Annual Report, 1885-6 (1891), and 14th Annual Report, 1892-3 (1896), pt. i.; also J. W. Jackson, *Manch. Memoirs* (*Lit. and Phil. Soc.*), vol. lx. (1916), No. 4. Abstract in *Nature*, January 27th, 1916.

[185] In the Ojibwa language, mī'gis = symbolical of life.

[186] The example figured by Hoffman (*op. cit.*, 1891, pl. xi., fig. 1) is interesting, as it is perforated at one end as if for suspension; it is of the dwarf var. *atava* of *C. moneta* (see *Fig.* 1*D*).

that which came into their possession through the hero-god Mī'nabō'zho.

The initiation ceremonies of these Indians are very elaborate: the most important incidents are dancing and the shooting forward by the medicine men of their skin medicine-bags containing the sacred cowries. Mystic powers are attributed to the shells, and it is firmly believed that if they be swallowed by the medicine man, he can transfer his power to the medicine-bag by breathing on it, the mysterious influence being then conveyed to the desired object or person merely by thrusting the bag forward in the appropriate direction. At the initiation ceremonies the magic influence is shot at the candidate's breast, and the cowry—the symbol of life—is supposed to enter his heart; he becomes unconcious and falls forward on his face. The chief medicine man then raises the candidate's head slightly from the ground, and a sacred cowry drops from the candidate's mouth.

The same cowries apparently play an important part at baptismal ceremonies of the Ojibwa. There is much dancing and the same shooting forward of the medicine bags, and after a good deal of facial contortion each medicine man spits out two shells on to a cloth spread in the middle of the medicine tent.[187]

The essential part of these ceremonies is the supposed death and survival of the candidate, the whole ceremonial being strongly reminiscent of the St. George, or Mummers', Plays of the Old World.[188] It is remarkable how closely the prevailing idea of the cowries being connected in some strange manner with resurrection and resuscitation agrees

[187] James Greenwood, "Curiosities of Savage Life," London, 1863, p. 24.

[188] For a full discussion of this subject see A. Beatty, "The St. George, or Mummers' Plays; A Study in the Protology of the Drama," *Trans. Wisc. Acad. Sci. Arts and Letters*, xv., pt. ii., Oct., 1906.

with the ancient Chinese belief as evidenced in the ceremonial use of money-cowries in obsequies of the dead. As mentioned previously, in pre-Christian and later times, cowries were used in China, in association with rice, for stuffing the mouth of the dead. Wild rice, it might be added, also enters into the ritual of Ojibwa and Menomini ceremonies. The fact that the so-called "wild rice" of America is not identical with true rice cannot be raised as an objection to the identity of these practices: for the similarity which suggested the name "wild rice" to European immigrants in America no doubt appealed with equal force to the earlier Asiatic rice-using immigrants.

The apparent identity in the spitting out of cowries by the Togo priests of West Africa and by the medicine men of the Ojibwa and Menomini Indians has been noted already. The association of the money-cowry with the medicine bags used by the Sierra Leone cannibals at initiation ceremonies is a further remarkable parallel.

Some interesting evidence of the early use of the money-cowry in North America is contained in an exhaustive account on "Aboriginal Sites on Tennessee River," by Mr. Clarence B. Moore.[189] In his description of the Roden Mounds, Marshall County, Alabama, this author informs us that in Burial No. 44, well in the body of mound A, were the remains of a skull, near which were fragments of a large marine univalve, and five shells, some much decayed, which had been pierced for stringing, like beads. These are pronounced by Dr. H. A. Pilsbry, the well-known American conchologist, to be examples of the money-cowry, *Cypræa moneta*, of Eastern Seas. Such shells have never been recorded before from an aboriginal mound in the United States. The careful investigation of the Roden mounds indicated that they had been built

[189] *Journ. Acad. Nat. Sci. Philad.*, 2nd Ser., xvi., pt. ii., 1915.

before their makers had any intercourse with white persons. The presence of the cowries, therefore, is of special interest.

The shells were sent by the discoverer to Dr. W. H. Dall, another of America's leading conchologists, and the following extraordinary statement was received in reply :—

> " I should incline to the belief that the cowries were imported in or about the time of Columbus' voyages. Bound, as they supposed, for the Indies, where the cowry was formerly (like our wampum) a staple article of barter, the exploring vessels would undoubtedly have carried cowries as well as the other articles of trade we know they carried. It would not have taken them long to find out that cowries did not pass as currency with American natives, and reporting this on their return to Spain later traders would not have carried them for barter. The necklace or bracelet you obtained may have passed from hand to hand as a curiosity (as I have known such things to do) until it reached a people who knew nothing of the whites 'till much later. In fact your cowries may have come off one of Columbus' own vessels ! "

But an even more remarkable story is that given in " Harper's Monthly Magazine " for September (1916, p. 599), by Mr. H. Newell Wardle, of the Philadelphia Academy of Natural Science, as follows :—

> " The great Genoese, starting in 1492 on his first voyage to discover a new route to the kingdom of the Great Khan, doubtless stocked his ships with a goodly store of these ivory-white porcelain shells. He had been in Guinea. He knew the requirements of the Gold Coast trade . . . . Probably, though he fails to mention it, cowries, strung as for the Guinea trade, were part of his stock—an ill-venture, in competition

with the shell ornaments of the Gulf Coast. . . . So mayhap the five little shells were bestowed, by Columbus's own hands, upon a native of the isles, were carried across to the mainland on some trip of trade or of pleasure, and thence, from hand to hand, as curios, journeyed northward with an ever-growing wonder-tale of the great white chiefs from the East. . ."

"If not thus, then they had journeyed in dangling from the trappings of one of those noble steeds that shared the perils of the early explorers of the mainland. . . ."

"Certain it is that they date from the close of the fifteenth or the early days of the sixteenth century."

But Mr. Wardle omits the most wonderful episode of his wonder-tale—I refer to the fact that after all these imaginary wanderings and episodes on sea and land, the cowries should eventually have come to rest in the heart of the American continent, and, "of course purely by accident," have become linked up with the identical beliefs and fantastic practices with which they are associated in Africa, India and Eastern Asia!

To such lengths does the American ethnologist go rather than admit the patent fact that these shells and the associated beliefs and practices were taken from Eastern Asia to America long before the time of Columbus!

According to Mr. Charles C. Willoughby, the Peabody Museum, Cambridge, Mass., contains a dress of a Cree woman, collected by the Lewis and Clark Expedition in 1804-5, on which are four dozen cowries (see *American Anthropologist*, 1905, for picture of the dress).

The shells from the Roden mound, Moore informs us, "differ from those on the Cree dress, which are of a larger variety and much more distinctly humped than are our

shells, ours being of the variety *atava*, as described by Rochebrune,[190] who says they come from the Cape Verde Islands" (see *Fig.* 1*C*).

Notwithstanding Rochebrune's assertion, few students of *Cypræa* admit the possibility of the occurrence of living *C. moneta* at the Cape Verde Islands, or indeed on any portion of the West African coast. The cited occurrences there of this and the allied form, *C. annulus*, may be due to accident. As already stated, enormous numbers of these shells have been carried to this coast during the last few centuries, and it is a well-known fact that ships conveying this commodity have occasionally come to grief, the cargo of shells being lost. Such an occurrence is recorded to have taken place in the year 1873, when the "Glendowra," a four-masted barque, homeward bound from Manilla, was wrecked off the coast of Cumberland. The "Glendowra" had on board some 600 bags of cowries (*C. moneta* and *C. annulus*) and missed the port of Liverpool through an error in her course, and, in the fog which prevailed, ran ashore near Seascale. For years these shells have been picked up, in good condition, on the sandy shore between Seascale and the river Calder, and collectors, unaware of their history, have regarded them as indigenous to the British Isles.[191]

Unfortunately, the precise distribution of the numerous varieties of *C. moneta* is not very well known. Hence it is not possible to be sure of the exact provenance of the Roden mound cowries, nor of those on the Cree dress. It may be of interest, however, to note that Dr. J. Cosmo Melvill, in his "Survey of the Genus Cypræa" (*op. cit.*, p. 240), gives India as a locality for the var. *atava*.

[190] *Bull. Soc. Malac. de France*, i., 1884, p. 83, pl. i., fig. 4 (copied in *Fig.* 1*C* of the present paper).

[191] See *The Naturalist*, London, Nov., 1890, p. 324.

Mr. Willoughby believes that cowry shells were sold to the Indians by the Hudson's Bay Company late in the eighteenth or early in the nineteenth century.

Prof. Henry Montgomery[192] records and figures a cowry found near the so-called Onatonabee Serpent Mound, Peterboro County, Ontario. Mr. C. B. Moore, (*op. cit.*, p. 295) says: "The shell described by Professor Montgomery is a regular *Cypræa moneta*, or money cowry of Africa and the East, and not a California shell. This shell, which, by the way, is not pierced for stringing, is probably one from the Hudson's Bay Company stock. We do not think the sale of cowries to Indians in the North at a comparatively late date by the Hudson's Bay Company indicates a relatively recent origin for the Roden mounds, for, at a period when the supplies of the Hudson's Bay Company could have reached the makers of the Roden mounds, articles of European make could have got among them from all directions and the mounds presumably would have been well supplied with glass beads, brass, iron, and other things obtained from European sources which, as we see, was very far from being the case."

In an old account by G. A. Cooke,[193] dealing with the habits and customs of the Indians of the most northern parts of America, some interesting particulars are given concerning the ceremonies observed by certain tribes previous to waging war. One of the most hideous of these, Cooke informs us, was the setting of the war-kettle on the fire, as an emblem that they were going out to devour their enemies. A *porcelane*, or large shell, was then dispatched to their allies, inviting them to come along and drink the blood of their enemies. Unfortu-

[192] *Trans. Canad. Inst.*, Toronto, 1910, ix. (i.) No. 20, p. 7, pl. iv., fig. 6 (*fide* Moore).

[193] Cooke, *op. cit.*, II., p. 21.

nately, neither the name of the tribes concerned, nor the name of the shell employed, are given; but the fact of the latter being called a "porcelane" is not without interest, as "porcelane" is the common French term for cowry. There is no certain evidence, however, to support the conclusion that a cowry was the shell employed as a war signal. Earlier in this paper we have seen that when the Egbas of West Africa meditated war, cowries were thrown into the air by the war-priest; and in the Yoruba country, where cowries are used for symbolic messages, a solitary cowry indicates defiance.

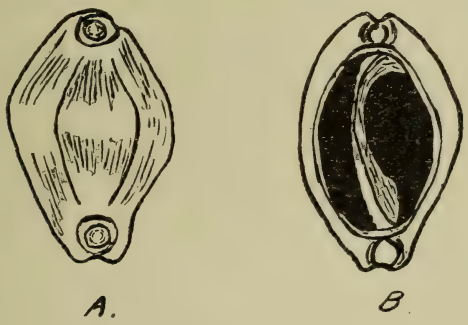


Fig. 4.

Ovula (*Calpurnus*) *verrucosa* L.

A.—Philippines (after Reeve).
B.—Ancient American graves (after Holmes).

Mr. W. H. Holmes, in his "Art in Shell of the Ancient Americans,"[194] illustrates in Plate xxxii. a number of perforated marine shells exhumed from ancient graves of North America. Two of these (Figs. 11 and 12) are of special interest as coming within the scope of the present communication. Unfortunately the precise data regarding the site of their discovery are not given; all we are told is

[194] Second Annual Report, Bureau of Ethnology, Washington, 1883, pp. 179-305.

that they are from the Pacific coast. Fig. 11 shows a cowry with a small hole near each extremity, illustrating, it is stated (p. 220), "an ancient as well as a modern method of perforation." The name of the species is not given, but it does not appear to me to be an American shell. Though the illustration is not sufficiently clear to define the species, in general appearance and contour the shell has a look of *Cypræa caput-serpentis*—an Indo-Pacific species.

Holmes' Fig. 12 (see *Fig.* 4*B*) shows a shell rubbed down on the back, and is referred, like the last, to *Cypræa*; but this is incorrect, the shell being undoubtedly *Ovula* (*Calpurnus*) *verrucosa*, L.[195] (*Fig.* 4*A*). This fact is of great importance and has hitherto passed unnoticed. Like the money-cowry, *C. moneta*, which it somewhat resembles, this species is alien to the American continent; it is known to occur only in East Africa, the Indian Ocean, Philippines, New Caledonia and neighbouring Islands.

According to Schmeltz (*op. cit.*, 1894, p. 34), this shell is worn as a neck-ornament in the Viti, or Fiji, Islands; as a hip-ornament in Santa Cruz (Queen Charlotte Islands); and as a leg-ornament in East New Guinea. The Rev. A. H. Cooke[196] also informs us that in Papua, "village elders are distinguished by a single *Ovulum verrucosum*, worn in the centre of the forehead."

The fact that the shell figured by Holmes is ground down on the back, as is done in the case of money-cowries in India, Africa, and other places, is of no little interest. Such an arbitrary method of perforation does

[195] The well-defined tubercles at the extremities confirm this identification. Compare, Tryon's "Manual of Conchology," vii., 1885, pl. 5, fig. 56-58 (Ovulidæ); Reeve, "Conchologia Iconica: Monograph of the Genus Ovulum," 1865, pl. i., fig. 2.

[196] "Molluscs," Camb. Nat. Hist., vol. iii., London, 1895, p. 99.

not seem to have been usual in shells other than cowries, either in America or anywhere else.

It is remarkable that after so many years, and with the yearly increase of knowledge, the two shells figured by Holmes should have remained undetermined. They are reproduced along with the other shells of Holmes' plate by H. Beuchat, on page 145 of his "Manuel d'Archéologie Américaine" (Paris, 1912), but no further details are added.

Regarding the use of cowries in Southern California, Frederick W. Putnam[197] gives some interesting particulars, though these are somewhat lacking in detail. He writes (p. 252): "The fact that the Indians of California, in common with savages generally, often decorated their implements and utensils with the same materials which they employed for personal ornament, is proved by articles collected from the graves; as, for instance, the decoration of the rims of the large stone mortars, on which, held in place by asphaltum, are pieces of the pearly shell of *Haliotis*, or sometimes, the perfect shells of two or three beautiful species of *Cypræa*; *C. spadicea* particularly being employed on the mainland. Another method of ornamenting the rims of these mortars consisted in cutting away the dorsal portion of the shells of *Cypræa* and fastening them to the mortar, by their cut surface, with asphaltum, so as to exhibit the lips of the shell, with their serrated edges." Such a cut shell is represented by Putnam in Plate xiii., Fig. 52, of his work, but no specific name is given. Its contour is totally unlike that of *C. spadicea*, or any other American cowry. My colleague, Mr. R. Standen, and I have carefully compared the illustration with various cowries, and the only shell the features of which appear

[197] In "Report U.S. Geog. Surv. west of 100th meridian, vol. vii.—Archæology," Washington, 1879.

to conform to the illustration is *C. vitellus*, an Indo-Pacific species. This suggestion, however, can only be a tentative one, as comparison with the original specimen may reveal other distinguishing characters not visible in the illustration.

A further interesting feature is seen in Putnam's Plate (Plate xiii, Fig. 47-51) in the use that was made by the Californians of cowry-shells for personal adornment. The serrated lips of these shells were cut out and perforated at one end for suspension as pendants. Earlier in this paper reference is made to the discovery of the complete outer lip of a large cowry (*C. tigris*) in prehistoric pit-dwellings in the South of England (*antea*, p. 11)

The discovery of cowries in pre-Columbian graves in Ecuador is recorded by M. H. Saville. In his "Antiquities of Manabi, Ecuador,"[198] this writer reports the finding of a shell of the cowry-type, which had a hole drilled in the top, and a piece of pottery was fitted to the under part by means of some kind of gum. This shell, which is figured by Saville (Plate lxvii., Fig. 5) as *Cypræa cervinetta* (a Panamic species), was found with a human skeleton in mound 3 at Cerro Jaboncillo.

[198] Contributions to South American Archæology, N.Y., 1910, vol. ii., pp. 48 and 177.

Manchester Memoirs, Vol. lx. (1916), *No.* **14.**

XIV.—The Specification of Stress. Part IV. (continued).

By R. F. Gwyther, M.A.

(*Received and read May 9th, 1916.*)

In Part IV. of this series of papers already published,* I withdrew from publication the Elastic Stress relations, except for Cartesian coordinates, and indicated only a method by which these relations might be obtained by the elimination of the elements of Strain in each case. I had it in my mind to replace this method by a simpler, and, as I then fancied, a more fundamental and instructive method.

I now consider that, except for mathematical simplicity or elegance, this method of elimination, though cumbrous, is instructive.

Before stating the several Stress relations, I will briefly indicate my view of their importance.

We commence the subject of Elasticity, confining the description to the statical case, with three mechanical equations regarding Stresses, and six expressions of Stress in terms of Strain, and usually eliminate the Stresses and obtain three differential equations conditioning the displacements.

In order to obtain the novel Stress relations we eliminate the Strains, and thus obtain equations containing no reference to displacements.

If we now return to the original sets of equations and

* *Manchester Memoirs*, Vol. lviii. (1914), No. 12.

consider the six expressions of Stress in terms of Strain we shall note that if u, v, w had been the components of any vector the steps in the further processes would be identical with those which we use when u, v, w are defined physically to be the displacement of the point in the body to which the elements of Stress refer.

The Stress relations will therefore be the same in form, whether u, v, w are definite physical vector functions of a point, or are arbitrary vector functions of that point, provided only the set of six expressions for Stress retain the same mathematical form. In other words, the Stress relations will hold not only for Elastic Stresses, but for stresses which have the general character of Elastic Stresses.

To present the question in another aspect. The equations which I have dealt with in this series of papers are general equations holding good at all points of a body, but no question will become definite until the surface-conditions are stated. These surface-conditions, in the simplest cases, will be either surface-traction conditions or surface-displacement conditions.

If the surface-conditions are surface-traction conditions only, the question of the physical interpretation of u, v, w will never arise. We should have the equations $na = S$, $nb = T$, $nc = U$ as the basis for a mathematical solution only.

If surface-displacement conditions are present, we should then meet the question of the interpretation of u, v, w. It appears a very extreme measure to decide that this is to be settled by a reference to Hooke's Law, when the issue depends on a surface-condition and not on a condition applying throughout the body.

The alternative is to regard u, v, w in the first instance as arbitrary, and thus obtain the Stress relations, and

finally, to determine u, v, w from the three equations given above, and to leave the definition of the, as yet, arbitrary vector for experiment and observation.

I have limited these remarks to the statical case, in which there is supposed to be an instantaneous change from one distribution of load to another, or in which, if there is a varying distribution of load, we have a statical question at each moment, and not a dynamical question from moment to moment.

There is, I imagine, no truly dynamical theory of Elasticity.

There remains the very interesting question of small oscillations about a position of statical equilibrium. Here we have, as Stokes pointed out, the evidence of isochronism of forced vibrations, and I give the Stress relations as applicable either to the statical case or to that of small oscillations.

Stress Relations.

(1) For Cartesian coordinate systems.

$$\rho\frac{\partial^2 P}{\partial t^2} - n\nabla^2 P = \frac{m(m-n)}{3m-n}\nabla^2(P+Q+R) + \frac{2mn}{3m-n}\frac{\partial^2}{\partial x^2}(P+Q+R),$$

$$\rho\frac{\partial^2 Q}{\partial t^2} - n\nabla^2 Q = \frac{m(m-n)}{3m-n}\nabla^2(P+Q+R) + \frac{2mn}{3m-n}\frac{\partial^2}{\partial y^2}(P+Q+R),$$

$$\rho\frac{\partial^2 R}{\partial t^2} - n\nabla^2 R = \frac{m(m-n)}{3m-n}\nabla^2(P+Q+R) + \frac{2mn}{3m-n}\frac{\partial^2}{\partial z^2}(P+Q+R),$$

$$\rho\frac{\partial^2 S}{\partial t} - n\nabla^2 S = \frac{2mn}{3m-n}\frac{\partial^2}{\partial y\partial z}(P+Q+R),$$

$$\rho\frac{\partial^2 T}{\partial t^2} - n\nabla^2 T = \frac{2mn}{3m-n}\frac{\partial^2}{\partial x\partial z}(P+Q+R)$$

$$\rho\frac{\partial^2 U}{\partial t^2} - n\nabla^2 U = \frac{2mn}{3m-n}\frac{\partial^2}{\partial x\partial y}(P+Q+R).$$

(2) For cylindrical polar coordinate systems.

$$\rho\frac{\partial^2 P}{\partial t^2} - n\nabla^2 P = \frac{m(m-n)}{3m-n}\nabla^2(P+Q+R) + \frac{2mn}{3m-n}\frac{\partial^2}{\partial r^2}(P+Q+R) - \frac{2n}{r^2}\left(P-Q+2\frac{\partial U}{\partial\theta}\right),$$

$$\rho\frac{\partial^2 Q}{\partial t^2} - n\nabla^2 Q = \frac{m(m-n)}{3m-n}\nabla^2(P+Q+R) + \frac{2mn}{3m-n}\left(\frac{1}{r}\frac{\partial}{\partial r} + \frac{1}{r^2}\frac{\partial^2}{\partial\theta^2}\right)(P+Q+R) + \frac{2n}{r^2}\left(P-Q+2\frac{\partial U}{\partial\theta}\right),$$

$$\rho\frac{\partial^2 R}{\partial t^2} - n\nabla^2 R = \frac{m(m-n)}{3m-n}\nabla^2(P+Q+R) + \frac{2mn}{3m-n}\frac{\partial^2}{\partial z^2}(P+Q+R),$$

$$\rho\frac{\partial^2 S}{\partial t^2} - n\nabla^2 S = \frac{2mn}{3m-n}\frac{1}{r}\frac{\partial^2}{\partial\theta\partial z}(P+Q+R) + \frac{n}{r^2}\left(2\frac{\partial T}{\partial\theta} - S\right),$$

$$\rho\frac{\partial^2 T}{\partial t^2} - n\nabla^2 T = \frac{2mn}{3m-n}\frac{\partial^2}{\partial r\partial z}(P+Q+R) - \frac{n}{r^2}\left(2\frac{\partial S}{\partial\theta} + T\right),$$

$$\rho\frac{\partial^2 U}{\partial t^2} - n\nabla^2 U = \frac{2mn}{3m-n}\left(\frac{1}{r}\frac{\partial^2}{\partial r\partial\theta} - \frac{1}{r^2}\frac{\partial}{\partial\theta}\right)(P+Q+R) + \frac{2n}{r^2}\left(\frac{\partial(P-Q)}{\partial\theta} - 2U\right).$$

(3) For spherical polar coordinate systems.

$$\rho\frac{\partial^2 P}{\partial t^2} - n\nabla^2 P = \frac{m(m-n)}{3m-n}\nabla^2(P+Q+R) + \frac{2mn}{3m-n}\frac{\partial^2}{\partial r^2}(P+Q+R) - \frac{2n}{r^2}\left\{2P-Q-R+2\frac{\partial T}{\partial\phi} - 2(1-x^2)\frac{\partial u}{\partial x} + 4xU\right\},$$

$$\rho\frac{\partial^2 Q}{\partial t^2} - n\nabla^2 Q = \frac{m(m-n)}{3m-n}\nabla^2(P+Q+R)$$
$$+\frac{2mn}{3m-n}\left\{\frac{1-x^2}{r^2}\frac{\partial^2}{\partial x^2}+\frac{1}{r}\frac{\partial}{\partial r}-\frac{x}{r^2}\frac{\partial}{\partial x}\right\}(P+Q+R)$$
$$+\frac{2n}{r^2}\left\{P-R-\frac{Q-R}{1-x^2}-2(1-x^2)\frac{\partial U}{\partial x}+2xU-\frac{2x}{1-x^2}\frac{\partial S}{\partial\phi}\right\},$$

$$\rho\frac{\partial^2 R}{\partial t^2} - n\nabla^2 R = \frac{m(m-n)}{3m-n}\nabla^2(P+Q+R)$$
$$+\frac{2mn}{3m-n}\left\{\frac{1}{(1-x^2)r^2}\frac{\partial^2}{\partial\phi^2}+\frac{1}{r}\frac{\partial}{\partial r}-\frac{x}{r^2}\frac{\partial}{\partial x}\right\}(P+Q+R)$$
$$+\frac{2n}{r^2}\left\{P-Q+\frac{Q-R}{1-x^2}+2\frac{\partial T}{\partial\phi}+\frac{2x}{1-x^2}\frac{\partial S}{\partial\phi}+2xU\right\},$$

$$\rho\frac{\partial^2 S}{\partial t^2} - n\nabla^2 S = -\frac{2mn}{3m-n}\left\{\frac{1}{r^2}\frac{\partial^2}{\partial x\partial\phi}+\frac{x}{(1-x^2)r^2}\frac{\partial}{\partial\phi}\right\}(P+Q+R)$$
$$+\frac{2n}{r^2}\left\{\frac{x}{1-x^2}\frac{\partial}{\partial\phi}(Q-R)-\frac{1+x^2}{1-x^2}S-(1-x^2)\frac{\partial T}{\partial x}+\frac{\partial U}{\partial\phi}\right\},$$

$$\rho\frac{\partial^2 T}{\partial t^2} - n\nabla^2 T = \frac{2mn}{3m-n}\left\{\frac{1}{(1-x^2)r}\frac{\partial^2}{\partial r\partial\phi}-\frac{1}{(1-x^2)r^2}\frac{\partial}{\partial\phi}\right\}(P+Q+R)$$
$$+\frac{2n}{r^2}\left\{\frac{\partial}{\partial\phi}(P-R)+\frac{\partial S}{\partial x}-\frac{2xS}{1-x^2}-x\frac{\partial T}{\partial x}-3T+\frac{2x}{1-x^2}\frac{\partial U}{\partial\phi}\right\},$$

$$\rho\frac{\partial^2 U}{\partial t^2} - n\nabla^2 U = -\frac{2mn}{3m-n}\left\{\frac{1}{r}\frac{\partial^2}{\partial r\partial x}-\frac{1}{r^2}\frac{\partial}{\partial x}\right\}(P+Q+R)$$
$$+\frac{2n}{r^2}\left\{\frac{\partial}{\partial x}(P-Q)-\frac{x(Q-R)}{1-x^2}-\frac{x}{1-x^2}(S+T)-x\frac{\partial U}{\partial x}-3U\right\}.$$

where $x=\cos\theta$, and where the actual stresses are P, Q, R, S, $T\sin\theta$, $U\sin\theta$.

LITERARY AND PHILOSOPHICAL SOCIETY,
36, George Street, Manchester.

PROCEEDINGS

OF

THE MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

British Association, September 8th—10th, 1915.

Members of the BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE were invited to an EXHIBITION OF APPARATUS, PORTRAITS, BOOKS, ETC., OF HISTORICAL INTEREST in the Society's House on the afternoons of Wednesday, Thursday, and Friday, the 8th, 9th, and 10th of September, at 4-30 p.m.

On Wednesday, the 8th, Professor Sir ERNEST RUTHERFORD, M.A., D.Sc., F.R.S., received members of Sections A and G (Mathematical and Physical Sciences, and Engineering); on Thursday, the 9th, Mr. FRANCIS JONES, M.Sc., F.R.S.E., F.C.S., received the members of Section B (Chemistry); and on Friday, The President (Professor SYDNEY J. HICKSON, M.A., D.Sc., F.R.S.) received members of Sections C, D, H, I and K (Geology, Zoology, Anthropology, Physiology and Botany).

A short account of the Society's history, by Mr. C. L. BARNES, M.A., together with a list of the various exhibits, was distributed to visitors during the meeting. These, and the frontispiece, a photograph of the Society's House, are reproduced here.

The Society's House.

BY

C. L. BARNES, M.A.,

Hon. Librarian.

A short account of the history of the Society, by the President, Professor S. J. HICKSON, will be found on pp. 90-92 of the *British Association Handbook*. The following remarks relate to the house and its contents.

Founded in 1781 (incorporated in 1875), the Society is one of the oldest scientific institutions in the world, yielding only in point of age to the Royal Society and several State-aided Academies on the Continent. This circumstance has enabled it to acquire, by exchange or purchase, the publications of well-nigh all the important scientific societies at home or abroad, from their foundation. A catalogue of this, the most valued possession of the Society, was issued in 1911, and copies are still available. It contains over 800 separate entries, and the proportion of missing numbers is insignificant.

A view of the house, 36, George Street, is shewn in the frontispiece. It has been the Society's meeting-place for nearly 120 years, but was originally much smaller than at present, the premises having been considerably enlarged in 1885, through the liberality of Dr. Henry Wilde, F.R.S.

On the left of the entrance is the Secretary's room, where Dalton, who lived not far away, carried on his experiments for many years. This fact is commemorated on a marble tablet over the fireplace. Here are also a small bust of Dalton, one of his barometers, an address presented to him by the Society in 1844, only a few months before his death, and several very delicate thermometers used by Joule in determining the mechanical equivalent of heat. The shelves contain a number of non-serial publications on Mathematics, Astronomy, Physics, Chemistry, Geology, and other sciences.

On the opposite side is the Council room, lined from floor to ceiling with French publications; these include the *Mémoires de l'Académie des Sciences* from 1666 onwards, the *Annales de Chimie et de Physique* from 1789, and the *Comptes Rendus* from 1835. On the mantelpiece is a chronometer watch used by Joule, and among the portraits on the walls is one of Bunsen and Kirchhoff, the former seated, the latter standing.

Passing by a small ante-room and a bronze bust of Dr. Angus Smith, we come to the largest room in the building, used for special lectures, and known as the Library, in which British serials are stored. Most of these emanate from London, though the chief provincial towns and cities are represented, from Aberdeen to York. As regards the *Philosophical Transactions*, the Society possesses what is virtually a complete set. The first 90 volumes were condensed by the Royal Society into 18, containing all the important papers up to that time; these, with the subsequent issues, are complete. Over the fireplaces are cases containing part of Dalton's chemical apparatus, the crudity of which need not be pointed out. The balance and weights, the thermometers, phials, measuring instruments, etc., are of a most primitive description, yet they were so used by him as to create an epoch in the history of chemistry.

In the basement are publications from Russia, Holland, Belgium, Spain, Portugal, Italy, Switzerland, and Scandinavia.

On the staircase leading to the first floor are a number of portraits of the Wilde lecturers, among them being Lord Rayleigh, Sir G. G. Stokes, Sir Michael Foster, Sir William Ramsay, Professor Frederick Soddy, Professor (now Sir) J. J. Larmor, Dr. (now Sir) J. A. Ewing, Dr. F. W. Clarke, Professor H. H. Turner, Dr. D. H. Scott, and Professor H. B. Baker.

The Dalton MSS. are kept in a case (presented to the Society by Sir Henry Roscoe, F.R.S.) on the landing, and above it is a photograph of the vestibule of the Manchester Town Hall, shewing the statues of Dalton and Joule. Dalton's physical apparatus is kept in a case at the end of the passage.

The Meeting-room is on the left, and contains some valuable furniture of Sheraton design. On the walls are portraits in oils of Newton, Davy, Dalton, Joule, Eaton Hodgkinson, Edward Holme, Thomas Henry, Edward W. Binney, Joseph Baxendell, Thomas Percival, and Peter Clare. There are also busts of Eaton Hodgkinson and William Henry. Over the President's chair is a marble tablet erected to the memory of Thomas Percival (joint-president 1782-1786, president 1789-1804). The clock—an excellent time-keeper—was made by Peter Clare, and has the peculiar property of striking once only every twelve hours. In the early days the Society was supposed to close its meetings at 9 p.m., whatever subject might be under discussion, and a single stroke from the clock warned them of the hour of departure. The time of striking can be altered at will.

A conjectural portrait of Newton investigating the solar spectrum is seen at the foot of a short flight of stairs leading to the Natural History room, so called because it was once occupied by a section, now defunct, whose microscopes and slides were handed over to the Society in 1902, and are on view. This room contains German and Austro-Hungarian publications.

On the second floor are publications from Canada, the U.S.A., Central and South America, Africa, Australasia, India, the Dutch East Indies, China and Japan.

Other exhibits are arranged as follows:—

A. Library.

Two Cabinets containing apparatus used by Dalton in his original investigations on the Atomic Theory, Vapour-Tensions, Radiant Heat, Meteorology, etc. (For Description see *Memoir* by Mr. Francis Jones.)

B. Council Room.

1. A Selection of early Works from the Society's Library.
2. Joule's Chronometer.
3. Portraits (See list in room).

C. Basement.

1. *Dalton's Diagrams relating to his Atomic Theory, Mechanics, Sound, Heat, Meteorology, Astronomy, etc. (For Description see *Memoir* by Professor W. W. Haldane Gee, Dr. H. F. Coward and Dr. Arthur Harden.)
2. *Atwood's Machine.
3. Three Kites, once the property of William Sturgeon, who made them after Franklin's models, with adjustments to enable them to take any angle with the vertical.
4. *Set of Pulleys.
5. *Inclined Plane.
6. *Wheel and Axle, and Worm and Cogwheel.
7. *Two Model Pumps.
8. *Simple and Compound Levers.
9. *Apparatus to illustrate the path of a projectile.
10. *Air Pump.
11. *Orrery.
12. *Planetarium.
13. Model of Semi-rotary Steam Engine. Lent by Dr. William Cramp.
14. *Model Beam Engine. By Clegg, David Street, Manchester.
15. *Model of Bunce's Pile Driver. By Clegg, David Street, Manchester.
16. *Whirling Table and accessories. By W. and S. Jones, Holborn, London. Nos. 2, 4, 5, 6, 8, 9, 10, 11, and 12 are also by this maker.

D. Landing.

1. Cabinet containing Manuscripts of John Dalton.
2. Bronze Bust of Dalton. Presented by Sir Henry Roscoe, F.R.S.
3. Portraits, etc. (See list on landing).

E. Ante-Room.

1. *Battery of 15 Leyden Jars.
2. *Metallic Thermometer.
3. *Two Earthenware Pots containing metal letter stamps, used by Dalton to mark his Barometers.
4. *Dalton's Hat. Maker, John King, Manchester.
5. *Dalton's Slippers.
6. *Dalton's "Hortus Siccus."
7. *Collection of Dalton's letters.
8. *Collection of Books written by Dalton.
9. *Letters of Jonathan Dalton to John Dalton.
10. Air Pump and accessories. An early possession of the Society. The pump was repaired by Peter Clare.
11. *Single-finger Clock.
12. *Pitch-Pipe.
13. *Tantalus Cup.
14. *Bennet's Electroscope.
15. *Electrophorus.
16. *Two Fulminating Panes.
17. Early form of Plate Electric Machine.
18. Barometers made by Dalton.
19. *Casting of Bismuth.

F. Meeting Room.

Biographies of Dalton, etc.

Case 1. (*a*) Medals awarded to John Dalton.

(*b*) Inkstand presented to John Dalton by the Mechanics' Institute, 1835.

(*c*) Japanese "Mirror." Made and presented by the late Mr. Thomas Thorp, F.R.A.S.

(*d*) Diffraction Gratings. Made and presented by the late Mr. Thomas Thorp, F.R.A.S.

Case 2. Selection of Papers, etc., relating to Dalton.

Case 3. Syllabuses of Dalton's Lectures.

Case 4. Dalton's Note Books and Meteorological Journals.

Case 5. Dalton's Account Books, Bank Book, and Kendal School Records.

Case 6. Selection of Dalton's manuscript Lecture Notes.

Diploma presented to Dalton by the Royal Medical Society of Edinburgh.

Portraits, etc. (See list in room).

G. Natural History Room.

1.*Dalton's Diagrams relating to Optics. (For Description see *Memoir* by Professor W. W. Haldane Gee, Dr. H. F. Coward and Dr. Arthur Harden.)

2.*A Two-foot Reflecting Telescope (Gregorian), with two eyepieces.

3.*Hadley's Sextant. By D. Adams, London.

4.*Terrestrial refracting Telescope.

5.*"Magic Lanthorn" and five coloured lantern slides.

6.*Drawing Camera.

7. Reflecting Stereoscope. By Watkins and Hill, London.

8.*One large concave Mirror (circular) and two small concave Mirrors (rectangular and circular).

9.*Model of human eye. By B. Martin, London.

10.*Microscope, Culpeper and Scarlet. A very primitive instrument made of wood with cardboard tubes. (1750.) (See Quekett's "Microscope," p. 22, fig. 20.)

11. Microscope, with cog-wheel to incline the instrument at a convenient angle. Made by Adams in 1776. Mahogany stand, with accessories, including boxes of slides.

12. Microscope, with case, lenses, etc. By B. Martin, London.

13. Microscope, Dr. Goring's improved reflecting, with case. By J. Cuthbert, London. (See Goring and Pritchard's "Micrographia," 1837.)

14. Microscope, binocular. By Powell and Lealand, London.

15. Microscope, binocular. By J. B. Dancer, Manchester.
Bears the inscription:—"Purchased by Members of the Microscopical Section of the Literary and Philosophical Society, Manchester, in remembrance of the late Professor Quekett, April, 1863."

16. Microscope, binocular. By J. B. Dancer, Manchester.
Bears the inscription:—"Microscopical and Natural History Section, Literary and Philosophical Society."
"Purchased by a few Members as a mark of respect and esteem for the memory of their friend John Parry, who died 27th, January, 1866."

17. Microscope, binocular. By Swift and Sons, London.
Bears the inscription:—"Presented to Mr. John Mullin. By the Principals and Employés as a token of respect, upon his leaving the service of William Holland and Sons, Victoria Mills, Miles Platting, Manchester. May, 1884."

18. Microscope, with case. With lenses, eye-pieces, and a collection of slides.

19. Cabinet containing Microscope accessories.

20. Lantern optical apparatus and case. By Newton and Co., London. Lenses:—Newton 3″, 2″, $1\frac{1}{2}$″, $\frac{8}{10}$″, $\frac{6}{10}$″, $\frac{4}{10}$″, total 6. Presented by Dr. Henry Wilde, F.R.S.

Those marked * are known to have belonged to Dalton, and were used by him in his lectures.

Ordinary Meeting, October 5th, 1915.

The President, Professor SYDNEY J. HICKSON, M.A., D.Sc., F.R.S., in the Chair.

Mr. C. L. BARNES, M.A., drew attention to the recent additions to the Society's Library, and a vote of thanks was accorded the donors of the books upon the table. The following works were included in the recent accessions to the Society's Library:

"*Royal Society Catalogue of Scientific Papers*," Fourth Series (1884-1900), Vol. XIII., A-B, and Vol. XIV., C-Fittig. (4to., Cambridge, 1914 and 1915), purchased; "*Geologic Atlas of the United States*," Folios Nos. 190-194 (fol., Washington, D.C., 1913-1914), presented by the United States Geological Survey; "*Report of the Sanitary Committee on the Subject of Air Pollution*," published by the Manchester Sanitary Committee (8vo., Manchester, 1915), presented by the Manchester Sanitary Committee; "*Essays on Milton*," by E. N. S. Thompson (8vo., New Haven, etc., 1914), and "*The Earliest Lives of Dante*," trans. from the Italian by J. R. Smith (Yale Studies in English) (8vo., New York, 1901), presented by Yale University Library; "*The Solar Rotation in June, 1911, from Spectrographic Observations*," by J. B. Hubrecht (4to., Cambridge, 1915), presented by the Author; "*Les Prix Nobel en 1913*" (8vo., Stockholm, 1914), presented by the Académie Royale Suédoise des Sciences; "*A Dictionary of the Choctaw Language*," by Cyrus Byington, ed. by J. R. Swanton and H. S. Halbert (Bulletin No. 46) (8vo., Washington, 1915), presented by the Bureau of American Ethnology, Washington, D.C.; "*The Fauna and Stratigraphy of the Kent Coal Field*," by Herbert Bolton (8vo., London, 1915), presented by the Author; "*List of Publications in the Bureau of American Ethnology with Index to Authors and Titles*" (Bulletin No. 58) (8vo., Washington, D.C., 1915), presented by the American Bureau of Ethnology, Washington, D.C.; "*Drachen Freiballon- und Fesselballon- beobachtungen*," by C. Braak (Verhandelingen No. 3) (8vo., Batavia, 1915), presented by the Koninklijk Magnetisch en Meteorologisch Observatorium te Batavia; "*Musée Teyler: Catalogue de la Bibliothèque*," dressé par J. J. Verwijnen, T. IV., 1904-1912 (4to., Harlem, 1915), presented by the Musée Teyler, Harlem; "*The Older Nonconformity in Kendal*," by Francis Nicholson and Ernest Axon (8vo., Kendal, 1915), presented by Mr. Francis Nicholson; and "*Photographic Magnitudes of Stars brighter than $9^{m}.0$ between Declination + 65° and Declination + 75°*" (4to., Edinburgh, 1914), presented by the Royal Observatory, Greenwich.

An exchange of publications has been arranged with the National Academy of Sciences, Washington, for their *Proceedings*.

The PRESIDENT referred to the exhibition arranged by the Society during the recent visit of the British Association, and drew attention to the pamphlet distributed to Members and Visitors on that occasion.

Mr. FRANCIS NICHOLSON, F.Z.S., made a short communication relating to the recent presence of Wheatears and other migratory birds on the Old Infirmary site.

Mr. C. L. BARNES, M.A., read the following note, relating to a visit to Dalton at his laboratory in the Society's house, taken from Granville's "Spas of England" (1841):—

"I found the great philosopher in the little laboratory of the institution, staring at me as if struggling to recognise an old acquaintance, whom length of time and his recent severe illness had probably obliterated from his intellect. Yet there still was upon his countenance that peculiar smile of benignity which ever distinguished his otherwise striking physiognomy. Dalton was in the act of endeavouring to loosen with patient placidity the stubborn glass stopper of an empty bottle, and welcomed me with a single smile, after a moment's hesitation, and a shake of the hand. Finding the effort difficult for him, "Friend" Clare, by whom I was escorted, and who will to the last day of his own useful life cherish the gratifying thought of having been the affectionate friend and helpmate of the great philosopher, offered to assist him. But Dalton, gently withdrawing his hand, which held the bottle, from Peter Clare's friendly offer, proceeded to a little lighted furnace, heated the bottle, and presently loosened the stopper, after which, as if he had been exhausted by the effort, he sat himself down and whispered with hesitation and difficulty some words, the meaning of which we did not catch. Peter, to rouse him, mentioned the last important papers on the phosphates, which Dalton had forwarded to the Royal Society in the April preceding; hearing which the philosopher instantly raised his eyes, and enquired if they had been read and published

in the Royal Transactions. Having given him a satisfactory answer, and alluded at the same time to our former and frequent meetings in that very hall more than a quarter of a century before, I took my leave of this venerable man, who, besides the admiration he was wont to excite before his dreadful attack of illness, was one of the greatest, yet one of the most simple-hearted men of his time, and even commands a higher degree of respect, not unmingled with a feeling of commiseration at his present enfeebled condition."

A paper by Mr. W. J. PERRY, B.A., entitled **"The Relationship between the Geographical Distributions of Megalithic Monuments and Ancient Mines,"** was explained by Mr. D. M. S. WATSON, M.Sc.

This paper is printed in full in the *Memoirs* with some Supplementary Remarks by Professor G. ELLIOT SMITH, M.A., M.D., F.R.S.

General Meeting, October 19th 1915.

The President, Professor SYDNEY J. HICKSON, M.A., D.Sc., F.R.S., in the Chair.

Mr. F. E. BRADLEY, M.A., M.Com., LL.D., Barrister-at-Law, *Stormarn, Wilbraham Road, Chorlton-cum-Hardy, Manchester;* Mr. J. C. MUNRO, *Clough House, Whaley Bridge;* and Mr. WILLIAM GRANVILLE PEMBERTON, Technical Chemist, *49, Acresfield Road, Pendleton*, were elected ordinary members of the Society.

Ordinary Meeting, October 19th, 1915.

The President, Professor SYDNEY J. HICKSON, M.A., D.Sc., F.R.S., in the Chair.

A vote of thanks was accorded the donors of the books upon the table.

The Society's *Memoirs and Proceedings* are now forwarded to the editor of the "*Subject Index to Periodicals*," published by "*The Athenæum*."

Mr. C. L. BARNES, M.A., read a communication entitled,

"A Lancashire Worthy."

In the quiet churchyard of St. Margaret's, Hollinwood, near the south-east corner of the Church, may be seen a tombstone with an inscription bearing testimony to the mathematical abilities of one James Wolfenden, who "born in a humble station of life, and compelled to toil as a weaver for his daily bread, self-instructed, became a distinguished mathematician, familiar with the writings of Simpson, Emerson, and the ancient geometry ..." A tablet in the Church itself, erected by "a grateful pupil," gives further evidence of his powers, and this is by no means empty flattery, as we shall proceed to shew.

One looks in vain for any mention of him in the "Dictionary of National Biography," nor does his name appear in the catalogue of the Reference Library, but a memoir by Thomas Wilkinson, of Blackburn, may be found in the "Mechanic's Magazine" for 1849, and he is given prominence in an article on "Lancashire Mathematicians," by Morgan Brierley, in the "Papers of the Manchester Literary Club," Vol. IV.

James Wolfenden was born in 1754, at Hollinwood, where his father, a native of Higginshaw, near Royton, had removed to follow his trade of hand-loom weaving. His mother was also of humble origin, so that on neither side was there any intellectual heritage or pre-disposition to mental endowment. By what process of telegony or fusion of qualities their only son was endowed with such unusual abilities can only be surmised. The boy was left motherless at an early age, and the father betook himself to Oldham, where young James received a rudimentary training in "the three R's" from a journeyman hatter. He was sent to school—for one week, and the whole cost of his education was 1½d. He was afterwards assisted by Jeremiah Ainsworth, a Hollinwood mathematician of some repute, but in the main he

was self-taught. All the leisure that could be spared from weaving was devoted to his beloved geometry, and with infinite toil he studied Euclid, Simpson's, and Emerson's "Exercises" and finally Newton, whose "Method of Prime and Ultimate Ratios" formed the basis of most of his work. He also studied Mechanics and Astronomy to good purpose, and was in fact, among the mathematicians of the second rank in the early 19th century.

In place of the "bridge problems," and other unproductive puzzle-competitions of the modern press, there were at that time a sufficient number of amateurs to fill pages of the "Ladies' Diary," the "Gentleman's Diary," "Burrow's Diary," "Whitley's Mathematical Delights," and other periodicals with problems often requiring much ingenuity, and Wolfenden contributed to these for upwards of sixty years. He proposed and solved such problems as the following:—"Given the base and vertical angle of a triangle, to construct it when the rectangle under the line bisecting the vertical angle and the difference of the sides is the greatest possible." "Suppose the sun and moon in the equinoctial, and the ratio of their forces to raise the tides given, to find by geometry the elongation when the interval or intercepted arc between the place of high water and the moon is the greatest possible." This last had been investigated by Bernoulli, by the aid of fluxions, but Wolfenden founded his solution on a Lemma to a proposition in Simpson's "Select Exercises." This was a kind of "tour de force" and shewed the power of geometry in capable hands. Newton, of course, was pre-eminent in this branch, but it was largely abandoned by his successors in favour of less severe methods.

He had many friends and admirers, and corresponded with a number of mathematicians, who were deeply impressed by his personality and attainments. If a large number of his letters had not been used by his grand-daughter to cover jampots, many interesting details might have been revealed, though several letters are quoted *in extenso* in Wilkinson's memoir already referred to.

Wolfenden pursued his humble occupation till he was 62

years of age, and for the next twenty-five years earned an exiguous income by teaching. He took pupils in Manchester and the neighbourhood, and was often urged to apply for an appointment, but when offered a post as schoolmaster at Liverpool he transferred it to William Hilton, a working man who had been fired by his own example, and is in all probability the anonymous "grateful pupil," who erected the tablet in the Church. He was Editor of the "Student" for some time.

As early as 1807 Wolfenden calculated the first tide-table for the port of Liverpool, published in the "Liverpool Almanac" for 1808. He continued to do this work for many years, receiving a small honorarium, which was withheld towards the close of his life, when he was in dire poverty. His circumstances becoming known, a number of members of the Manchester Literary and Philosophical Society—then under the presidency of Dr. Eaton Hodgkinson—together with other charitable persons, subscribed a sum sufficient to provide him a modest annuity, but—we quote further from the tombstone—"his death occurring shortly after, they determined, besides bearing the expense of his funeral, to place this stone over his remains to perpetuate the memory of his name and merits." The stone is in good condition, and the inscription sets forth that in the same grave lie Matty, his wife, who died in 1784, a few years after the marriage; their son John, and his wife Charlotte.

The action of the Society did not escape the censure of a critic who concluded a poem of 47 lines with the words "He asked for bread, and he received a stone," but it was kindly meant, and Wolfenden, who was a sturdy, independent character, no doubt tried to conceal his poverty as much as possible. His wants were few at any time, though, in extreme old age, he had little, if anything, beyond the bare necessaries of life. After three-quarters of a century there is not likely to be anyone living who can recall his appearance, but the Society possesses an unnamed bust which, by what is known in mathematics as the "method of exhaustions," is almost certainly his. No portrait is

available for comparison, but the features are decidedly intellectual, though one would hesitate to call them aristocratic.

Mr. W. C. JENKINS, F.R.A.S., read a note on "**Rainfall in Manchester, 1915.**"

Having noticed frequent references in the press as to a shortage of water in this neighbourhood, a review of the records of rainfall may be of interest.

In general there is no abnormal shortage in amount. The period, March to June, was $2\frac{1}{4}$ inches below the average, but this was recovered during July. As to the effect of these dry months, they barely compensated for the very wet period from November to February when the fall was 5 inches above the average.

During the past six weeks the measured amount has only totalled $\frac{3}{4}$ inch.

I give in the following table the monthly amounts of Rainfall measured at the Godlee Observatory, compared with average values for the district based on records of the past 60 years, for the twelve months commencing November last, this gives the current month a full amount for average and only the measured quantity to date. Otherwise to the end of September the last period is only half an inch short.

RAINFALL IN MANCHESTER.

	1914-15.		Average, 60 yrs.	
November	3·597		2·737	
December	4·776		3·103	
January	4·756	Nov. to Feb.	2·553	
February	2·480	*15·609*	2·040	*10·433*
March	1·320		2·328	
April	1·319		1·799	
May	1·372	March to June	2·131	
June	2·741	*6·752*	2·745	*9·003*
July	5·029		3·108	
August	3·636		3·573	

	1914-15.		Average, 60 yrs.
September	0·537	July to Oct.	3·114
October (to 18th)	0·293	*9·495*	3·589 *13·384*
Total to Oct. 18th...	31·856		32·820 Average for year.

Professor G. ELLIOT SMITH M.A., M.D., F.R.S., made a short communication on **"The Evidence afforded by the Winged-Disc in Mexico and Central America for the Egyptian Origin of Certain Elements of the Pre-columbian Civilization.**

In a previous communication to the Society the author cited a very large series of curious customs and beliefs, built up into an artificial culture-complex, as a demonstration of the fact that the ancient civilisation of America was derived from the Old World. The proof is further corroborated and put beyond all reasonable doubt when each of its numerous component elements is studied; for it is found that not only are the wider cultural associations of each factor reproduced in the New World, but also in many cases trivial details of designs and customs

The distinctively Egyptian, and wholly arbitrary, association of the sun's disc with two serpents and hawk's wings, is found represented on the lintel of the sanctuary in many ancient sun-temples in Mexico and Central America. In the course of its transference from the Old World to the New this curious design became reversed—upside down—and the lattice-pattern of the serpents' bodies, often seen in the Egyptian examples, became still further conventionalised to form a purely geometrical pattern, in which the serpent is no longer recognisable as such, although the symbol is known to be that of a serpent-deity. Comparison with the Egyptian examples explains the meaning of these hitherto-inexplicable features in the American symbolism. The modifications which the Egyptian design underwent in Syria and Babylonia, where the disc is sometimes replaced by a representation of some deity, also explain some of the American variants of the pattern. Incidentally the American symbols

afford an admirable illustration of Rivers' view that the transformation of a naturalistic into a geometrical conventional design is often due to the blending of different cultural ideals (*Report Brit. Assoc.*, 1912, p. 599).

A paper, entitled **"Notes on some Palæozoic Fishes,"** was given by Mr. D. M. S. WATSON, M.Sc., and Mr. HENRY DAY, M.Sc.

This paper is printed in full in the *Memoirs*.

General Meeting, November 2nd, 1915.

Mr. FRANCIS JONES, M.Sc., F.R.S.E., F.C.S., in the Chair.

Mr. G. A. HAMLYN, B.A. (Oxon.), Assistant Lecturer and Demonstrator in the Fermentation Industries, The Municipal School of Technology, Manchester, was elected an ordinary member of the Society.

Ordinary Meeting, November 2nd, 1915.

The President, Professor SYDNEY J. HICKSON, M.A., D.Sc., F.R.S., in the Chair.

Mr. R. L. TAYLOR, F.C.S., F.I.C., read a paper entitled **"Notes on Hypochlorous Acid and Chlorine."**

Mr. Taylor described and discussed some further recent experiments with hypochlorous acid, which was prepared, as described in former papers, by distilling a solution of bleaching powder with boric acid. He showed how a solution of an alkaline hypochlorite rapidly changes ordinary precipitated oxide of silver into black peroxide, closely approximating in composition to that represented by the formula Ag_2O_2.

Experiments were described in which comparison was made between the bleaching activities of hypochlorous acid and chlorine, the conclusion arrived at being that, contrary to the general opinion, the latter is considerably the more active of the two.

The remarkable effect of a very dilute solution of chlorine on litmus was shown. The litmus is at once turned a bright red colour, which rapidly changes back to purple, and this slowly bleaches. From this result Mr. Taylor concludes that the usual explanation of the bleaching action of chlorine (in the case of litmus, at any rate) is not correct, but that the chlorine acts by directly chlorinating the colouring matter.

Reference was also made to the recent use of hypochlorous acid as the "ideal antiseptic." Professor Lorrain Smith uses either a powder, which he calls "Eupad," made by intimately mixing powdered bleaching powder and boric acid, or a solution obtained by treating the powder with water, and which he calls "Eusol." In both the moistened powder and the solution as used by Professor Lorrain Smith there will be a considerable amount of hypochlorous acid, but there will also inevitably be a certain amount of free chlorine. Dr. A. Carroll and Mr. H. Dakin, who have apparently arrived independently at the same conclusion as to the great value of hypochlorous acid as an antiseptic, recommend the use of bleaching powder mixed with boric acid and carbonate of lime. The use of the last-named substance would have the effect of getting rid of most, if not all, of the free chlorine referred to above.

General Meeting, November 16th, 1915.

The President, Professor SYDNEY J. HICKSON, M.A., D.Sc., F.R.S., in the Chair.

Mr. DONALD WARD CUTLER, B.A. (Cantab.), Scholar of Queens' College, Cambridge, Assistant Lecturer and Demonstrator

in Zoology in the Victoria University of Manchester, and of *69, Mauldeth Road, Withington, Manchester*, was elected an ordinary member of the Society.

Ordinary Meeting, November 16th, 1915.

The President, Professor SYDNEY J. HICKSON, M.A., D.Sc., F.R.S., in the Chair.

Dr. G. A. HEMSALECH, F.R.A.S., read a paper entitled, **"On the Spectra emitted by metal vapours in the explosion region of the air-coal-gas flame."**

After a review of the work done on Bunsen flame spectra by M. de Watteville and on the different flame spectra of calcium and iron by Hemsalech and de Watteville, the author described a simple and convenient burner by means of which the various flame phenomena can be readily subjected to spectroscopic observation and experiment. Photographs were shown to illustrate the changes in the Swan spectrum emitted by the explosion region of flames on passing from rich to very weak gas mixtures. For very weak mixtures the ordinary Swan spectrum disappears and another band spectrum develops.

Some experiments were then shown to demonstrate the action of electric fields on the flames of weak gas mixtures charged with sodium vapour. The great sensitiveness of such flames in a longitudinal field was illustrated in several ways, and, in particular, it was shown that when the gas mixture had become so weak that in the absence of the electric field it would no longer ignite, it would do so immediately on the field being restored.

General Meeting, November 30th, 1915.

The President, Professor SYDNEY J. HICKSON, M.A., D.Sc., F.R.S., in the Chair.

Councillor ERNEST DARWIN SIMON, *Moorlands, Fog Lane, Didsbury*; and Sir HENRY ALEXANDER MIERS, M.A., D.Sc., F.R.S., Vice-Chancellor of the Victoria University of Manchester, *The University, Manchester*, were elected Ordinary Members of the Society.

Ordinary Meeting, November 30th, 1915.

The President, Professor SYDNEY J. HICKSON, M.A., D.Sc., F.R.S., in the Chair.

A vote of thanks was accorded the donors of the books upon the table. The recent additions to the Society's Library included: "*Flora Capensis*," Vol. V., Sect. II., Pt. ii. by Sir W. Thiselton-Dyer (8vo., London, 1915), purchased; "*Oudheidkundige Dienst in Nederlandsch-Indië, Oudheidkundig Verslag*," 1915, 1^e^K. (8vo., Batavia, etc., 1915) and *Rapporten, van den Oudheidkundigen Dienst in Nederlandsch-Indië*," 1914, 1^e^K. (4to., Batavia, etc., 1915), presented by the Bataviaasch Genootschap van Kunsten en Wetenschappen; "*The Library of Harvard College*," by A. C. Potter, 3rd. ed. (8vo., Cambridge, Mass., U.S.A., 1915), presented by Harvard College Library; and "*Archaeologia*," Vol. 18, Pt. I. and Vol. 26 (4to., London, 1815 and 1836), purchased.

Professor G. ELLIOT SMITH, M.A., M.D., F.R.S., gave some

"Further Notes on Pre-Columbian Representations of the Elephant in America."

These notes were an amplification of the letter published in *Nature*, November 25, 1915, p. 340. Further examples of representations of the elephant were shown; and attention was

called to the fact that the Hindu god Indra, who was associated with the elephant, killed Vritra, who kept the rain in the clouds, just as the Central American elephant-headed god stood upon the head of the serpent who prevented the rain from reaching the earth.

Mr. T. A. COWARD, F.Z.S., F.E.S. read a paper entitled "**A Change in the Habits of the Black-headed Gull.**"

This paper is printed in full in the *Memoirs*.

Ordinary Meeting, December 14th, 1915.

The President, Professor SYDNEY J. HICKSON, M.A., D.Sc., F.R.S., in the Chair.

Mr. F. G. PERCIVAL, B.Sc., read a paper entitled "**The Punctation of the Brachiopoda.**"

The shells of the Terebratulaceæ are perforated by thousands of little pores, through which pass tube-like processes of the mantle. The number of these puncta per sq. mm. varies in different species, and this variation has been used as a means of distinguishing between different species.

Unfortunately, an examination of large numbers of individuals belonging to one species shows that the variation within a single species is so great as to render the character useless as a means of distinction; e.g. 166 individuals of *Terebratula biplicata*, (Brocchi), were examined and the puncta were found to range from 39 to 129 per sq. mm. Similarly 367 specimens of *T. punctata*, Sow. showed a total range from 66 to 240 per sq. mm. All the readings were taken at approximately the same distance from the umbo, because the number per sq. mm. increases with the distance from this point.

These two species alone cover the greater part of the total variation possible for the group, and the variation is therefore almost useless as a means of specific distinction.

Mr. J. WILFRID JACKSON, F.G.S., read a paper entitled **"The Money Cowry as a Sacred Object among North American Indians."**

The same Author read a further paper entitled **"The Aztec Moon-cult and its relation to the Chank-cult of India."**

These papers will be printed in full in the *Memoirs*.

Professor G. ELLIOT SMITH, M.A., M.D., F.R.S., read a paper entitled **"Further Evidence for the Derivation of Elements of Early American Civilization from the Old World."**

Discussing the significance of pre-Columbian representations of the elephant in American sculptures and codices (already summarised in *Nature*, November 25, 1915, p. 340, and December 16, p. 425), and making use of the evidence supplied by truncated pyramids and the winged-disc symbolism in substantiation of the influence of Egypt and Asia, attention was called to the fact that a great part of the ancient Indian pantheon, centred around the god Indra, had been bodily adopted by the Maya people of Central America. Evidence was adduced to explain the details of the process of transmission (which probably began somewhere about 200 B.C. and continued for many centuries) and the confusion which was introduced during the migration. Particular attention was called to the great influence exerted by the late conventionalised form of the Indian Makara, as a sea-elephant, in determining the design not only of the Copan elephants in the far east, but also of the early Christian and pre-Christian representations of the elephant upon the sculptured stones of Scotland and Scandinavia in the far west.

The fact was again emphasised that practically every element of the early civilisations of America was borrowed from the Old World. Small groups of immigrants from time to time brought to America certain of the customs, beliefs and inventions of the Mediterranean area, Egypt, Ethiopia, Arabia, Babylonia, India, Indonesia, Eastern Asia, and Oceania; and

this confused jumble of practices became assimilated and "Americanised" in their new home across the Pacific, as the result of the domination of the great uncultured aboriginal populations by small bands of more cultured foreigners.

Ordinary Meeting, January 11th, 1916.

The President, Professor SYDNEY J. HICKSON, M.A., D.Sc., F.R.S., in the Chair.

A vote of thanks was accorded the donors of the books upon the table. These included: *Svensk Naturskyddsbibliografi, 1901-1912*" (8vo. Uppsala, etc., 1913), presented by the K. Svenska Vetenskapskademie, Uppsala; "*Triangulation in Alabama and Mississippi*," by W. F. Reynolds (Special Publication, No. 24) (4to., Washington, D.C., 1915), presented by the United States Coast and Geodetic Survey, Washington; and "*Coptic Cloths*," by Laura E. Start (4to., [Halifax], 1914) (Bankfield Museum Notes, 2nd Series, No. 4), presented by the Authoress.

The PRESIDENT referred to the death of Sir HENRY ENFIELD ROSCOE, LL.D., D.C.L., F.R.S. Sir Henry Roscoe was elected an Ordinary Member of the Society in 1858; was President in 1882-4; and was elected an Honorary Member in 1897.

The PRESIDENT exhibited a large Conch-shell and made a few remarks on the use of such shells as musical instruments.

He afterwards delivered an address entitled "**Animal symmetry and the differentiation of species.**"

This Address is printed in full in the *Memoirs*.

Ordinary Meeting, January 25th, 1916.

The President, Professor SYDNEY J. HICKSON, M.A., D.Sc., F.R.S., in the Chair.

A vote of thanks was accorded the donors of the books upon the table. These included: "*A Revision of the Ichneumonidae...Brit. Mus.* (*Nat. Hist.*)," Pt. IV., by Claude Morley (8vo., London, 1915), "*A Guide to the Fossil Remains of Man... Brit. Mus.* (*Nat. Hist.*)" (8vo., London, 1915), and "*Instructions for Collectors, No. 12, Worms*," by H. A. Baylis (8vo, London, 1915), presented by the Trustees of the British Museum (Nat. Hist.).

Professor F. E. WEISS, D.Sc., F.L.S., drew attention to the death in November last year of Count SOLMS-LAUBACH, who was elected an honorary member of the Society in 1892. Count Solms was born in 1842, and came of one of the most ancient of German families. He was Professor of Botany at the University of Göttingen, and subsequently at that of Strasburg, from which post he resigned a few years ago. He was a man of wide interests, and had contributed to the advance of many sides of botanical science by his investigations. Latterly his interests centred largely in Palaeobotany, and probably his introduction to Palaeophytology, of which the Clarendon Press has issued an English translation, is the most important of his more recent publications. Count Solms was a man of unassuming character who had many staunch friends in this country.

Professor WILLIAM H. LANG, M.B., D.Sc., F.R.S., exhibited a dirty paper-like substance which he said was composed of unbranched filaments of Algae—probably two species—and which had been found by Professor Sydney J. Hickson, on the margin of a small pond in North Wales. The material, however, had dried up, leaving only the cell walls.

Dr. H. F. COWARD and Mr. F. BAILEY showed **"A simple experiment illustrating the causes of luminosity of coal-gas flames."**

A stream of coal-gas was passed through a tube immersed in solid carbonic acid and ether, at —79°C. This condensed completely all the benzene, toluene and similar substances, but allowed the whole of the ethylene to pass forward with the gas. The luminosity of the flame of the issuing gas was very feeble in comparison with that of the original gas. Measurements carried out by Mr. W. Buckley at the Corporation Gas Works in Rochdale Road, showed that a particular coal-gas lost 78 per cent. of its illuminating power by this treatment. The benzene hydrocarbons therefore contribute far more to the luminosity of coal-gas flames than does ethylene, in spite of the fact that the volume of ethylene present is usually three to five times the volume of benzene vapour.

A discussion on the PRESIDENT'S ADDRESS—**"On animal symmetry and the differentiation of species"**—was opened by Dr. W. M. TATTERSALL.

Dr. Tattersall urged :—

1. That radial symmetry is the direct outcome of a sedentary habit and is more primitive than bilateral symmetry. It appears in its most complete and primitive form in Coelenterates and Echinoderms, where it affects both external and internal structures. These groups of animals probably arose as fixed forms before the appearance in the animal world of movement by muscular effort. With the development of the latter type of locomotion, radial symmetry was gradually eliminated in favour of bilateral symmetry. All the higher groups of animals are bilaterally symmetrical, and radial symmetry only appears in those forms, such as sedentary Worms, Polyzoa, Tunicata, which have secondarily acquired a sedentary habit. In such cases the radial symmetry is secondary and superficial, only affecting the external organs.

2. In those groups of fixed animals exhibiting primitive radial symmetry, the Coelenterates, two types of variation are found, (1) congenital variation, *i.e.*, the variation of hereditary characters, unaffected by the environment, and (2) vegetative

variation, due to the direct action of the environment. Congenital variation has not been proved to be more intensive among radially symmetrical animals than among bilaterally symmetrical forms. This type of variation alone is of importance in the evolution of discontinuous specific groups. Vegetative variation is characteristic of fixed forms and is the direct result of a sedentary life. It is a measure of the adaptability of the animal to its environment, and is practically unknown in free-living bilaterally symmetrical animals. It is of no value in the evolution of discontinuous specific groups. There is no correlation between radial symmetry and vegetative variation, except in so far as both are the result of a fixed habit of life.

3. Systematic Zoologists have hitherto attempted to distinguish discontinuous specific groups among radially symmetrical animals on characters which are the result of vegetative variation, and have found difficulty in doing so satisfactorily. This is, however, no evidence that such groups do not exist. A study of those parts of radially symmetrical animals which are less liable to the effects of the environment and therefore more constant in character will probably yield results of importance for the discrimination of species. Such work has already yielded encouraging results among Corals, one of the most variable groups of radially symmetrical animals. Until more such work has been done and the results examined it is premature to deny the existence of discontinuous specific groups in radially symmetrical animals.

Sir HENRY MIERS, M.A., D.Sc., F.R.S., called attention to the radical difference between the symmetry of an organism and that of a crystal. Individual crystals display bilateral or multilateral symmetry, and a group of crystals may display radial symmetry but always of a two-, three-, four-, or six-fold character; and this is now known to be a consequence of the homogeneity of a crystal. He asked whether anything is known of the cause which determines the number of repetitions in a normal specimen of a radially symmetrical organism.

Professor WILLIAM H. LANG, M.B., D.Sc., F.R.S., considered, in the light of the principles contained in the President's Address, some cases of dorsiventral symmetry of cryptogamic plants. It seemed difficult to apply these principles to the plants, where symmetry often appeared to rest on deeper and still unexplained differences of the germ cells. There was no reason to believe that specific differences were less readily drawn in radial than in dorsiventral plants.

Mr. D. THODAY, M.A., suggested that some degree of plasticity, expressed in a certain range of variability, might be explicable on the analogy of allotropic forms of crystals, without assuming any more fundamental change of "specific substance." The known properties of fibres and other plant structures demanded a definite arrangement of the particles composing them, so that they could hardly be termed amorphous; at the same time their chemical complexity suggested the possibility of a greater variety of modes of arrangement, and perhaps also less definiteness and stability, than were exhibited by the crystalline forms of relatively simple substance. Such a mode of arrangement in substances formed by the protoplasm might be a reflection of a corresponding structural arrangement in the protoplasm; and this might be in some degree hereditary, though more susceptible to environmental influences than the chemical composition of the "specific substance."

The PRESIDENT in reply said that he was prepared to admit that in the evolution of the animal kingdom as a whole the sedentary habit came first and the radial symmetry followed, but he joined issue with Dr. Tattersall as regards the relative variability of radially symmetrical and of bilaterally symmetrical animals.

It is quite true that in some Coelenterata the radial symmetry is remarkably constant, as for example the octoradial symmetry of the Alcyonaria, but when variation does occur, as for example in Medusae and Sea-anemones, it affects important vital organs such as the stomach, gonads and sense organs to a

degree quite unknown among bilaterally symmetrical animals. The method of branching in Corals and other zoophytes cannot be regarded as a purely vegetative variation, otherwise all zoophytes living under like conditions would be alike, and they are not. The President regarded the discussion as interesting and suggestive. It might lead to some modification of the views expressed in his Address, and some further illustration and explanation of other points.

Ordinary Meeting, February 8th, 1916.

The President, Professor SYDNEY J. HICKSON, M.A., D.Sc., F.R.S., in the Chair.

A vote of thanks was accorded the donors of the books upon the table. The recent accessions to the Society's Library included: "*Canadian Institute.—General Index to Publications, 1852-1912*," by John Patterson (4to., Toronto, 1914), presented by the Canadian Institute, Toronto; "*On the Igneous and Pyroclastic Rocks of the Berwyn Hills...*," by T. H. Cope (8vo., Liverpool, 1915), presented by the Liverpool Geological Society; and "*The British Marine Annelids*," by W. C. McIntosh, Vol. III., Pt. II., Plates, published by the Ray Society (fol., London, 1915), purchased.

Mr. E. L. RHEAD, M.Sc.Tech., F.I.C., and Mr. W. C. JENKINS, F.R.A.S., were nominated Auditors of the Society's accounts for the session 1915-16.

In a communication on "**New Phases of the Controversies concerning the Piltdown Skull,**" Professor G. ELLIOT SMITH, M.A., M.D., F.R.S., considered the different views that had been recently expressed; (1) that the canine belonged to the upper and not the lower jaw; (2) that the mandible was not human, but that of a hitherto unknown species of chimpanzee, which by some unexplained means made its way into England in the Pleistocene period; (3) that the features

differentiating this mandible from that of modern man had been unduly exaggerated; (4) that the canine tooth could not have belonged to the same individual as the skull and the jaw because it differed from them in age, according to one authority being definitely *older*, and to another distinctly *younger*, than the other fragments. These widely divergent views tend to neutralise one another.

In considering the possibility that more than one hitherto unknown ape-like man or man-like ape expired in Britain side by side in the Pleistocene period, and left complementary parts the one of the other, the element of improbability is so enormous as not to be set aside except for the most definite and positive anatomical reasons. The evidence submitted in support of each item of the arguments for the dissociation of the fragments was examined; and it was maintained that none of it was sufficiently strong to bear the enormous weight of improbability which these hypotheses imposed upon it.

The author called special attention to the implied inference that the cranium itself was not sufficiently simian to be associated with the jaw; and emphasised the fact that the skull itself revealed certain features of a more primitive nature than any other known representative of the human family.

A paper by Mr. W. J. PERRY, B.A., entitled "**The Geographical Distribution of Terraced Cultivation and Irrigation,**" was read by Professor G. ELLIOT SMITH.

This paper is printed in full in the *Memoirs*.

Mr. J. WILFRID JACKSON, F.G.S., read a paper entitled "**The Geographical Distribution of the Shell-Purple Industry.**"

The same Author read a further paper entitled "**Shell-Trumpets and their Distribution in the Old and New World.**"

These papers are printed in full in the *Memoirs*.

General Meeting, February 22nd, 1916.

Professor G. ELLIOT SMITH, M.A., M.D., F.R.S.,
Vice-President, in the Chair.

Mr. LAWRENCE W. BALLS, M.A., Research Botanist to the Fine Cotton Spinners Association, St. James's Square, Manchester, and of *Bramhall, Cheshire*, was elected an ordinary member of the Society.

Ordinary Meeting, February 22nd, 1916.

Professor G. ELLIOT SMITH, M.A., M.D., F.R.S.,
Vice-President, in the Chair.

A vote of thanks was accorded the donors of the books upon the table. These included :—"*The Athenæum Subject Index to Periodicals 1915. Science and Technology*," (4to, London, 1916,) presented by the Publishers; "*Mneuosynon. Carmen Francisci Xaverii Reuss...*," (8vo., Amstelodami, 1915), presented by the Koninklijke Akademie van Wetenschappen, Amsterdam); and "*Catalogue of Ta-jih-pên-hsü-ts'ang-ching*," transliterated by Daitarō Saeki (8vo., Kyoto, 1915), presented by the Zōkyo Shoin Company, Tokyo.

Mr. C. E. STROMEYER, M.Inst.C.E., M.Inst.M.E., shewed that the water hammers which result if a straight tube containing water and its vapour be subjected to vertical jerks occur near the surface if the tube has been standing for some time, and near the bottom if the water has been agitated. He also pointed out that it is rather difficult to explain why a water column ruptures under weak forces, for the surface tension of an infinitely small vacuum bubble is very great.

Professor W. W. HALDANE GEE, B.Sc., M.Sc.Tech., showed **some experiments with Bunsen and Luminous Flames.**

When a flame is produced by coal gas issuing from a small circular nozzle a small obstacle placed at the centre of the flame, at a critical distance a few inches above the aperture, gives rise to a musical note of high frequency. If two such flames are made to impinge, roaring or musical flames result. Burners of the Bray and Mēker type were shown to have special properties. An experiment of great interest enabled the eddy currents produced by a flame from a triple nozzle to be studied. When the flame is adjusted—so as to be central within a wide glass tube—carbonaceous particles are precipitated from the flame and these are whirled in an infinite variety of curves round the flame mantle. The effect is more marked when benzine is introduced into the coal-gas.

Dr. J. H. SMITH, F.I.C., read a paper entitled **"A resumé of work on the bleach-out process of colour photography."**

This paper will be printed in full in the *Memoirs*.

Ordinary Meeting, March 7th, 1916.

The President, Professor SYDNEY J. HICKSON, M.A., D.Sc., F.R.S., in the Chair.

A vote of thanks was accorded the donors of the books upon the table. The accessions to the Society's library included: "*Numbers, Variables and Mr. Russell's Philosophy*," by R. P. Richardson and E. H. Landis (8vo., Chicago and London, 1915) and "*Fundamental Conceptions of Modern Mathematics, Variables and Quantities*" by R. P. Richardson and E. H. Landis (8vo., Chicago and London, 1916), presented by the Authors; "*The Principles of Plant-Teratology*," by W. C. Worsdell, vol. I. (8vo., London, 1915) and "*The British Freshwater Rhizopoda and Heliozoa*, Vol. III. '*Rhizopoda*,' Part iii." by G. H. Wailes

(8vo., London, 1915), published by the Ray Society, purchased; "*Results of Magnetic Observations made by the United States Coast and Geodetic Survey in 1914*," by D. L. Hazard (Special Publication No. 25) (4to., Washington, 1915), "*Distribution of the Magnetic Declination in the United States for January 1, 1915*," by D. L. Hazard (Special Publication No. 33) (8vo., Washington, 1915), and "*Application of the Theory of Least Squares to the Adjustment of Triangulation*," by O. S. Adams (Special Publication No. 28) (8vo., Washington, 1915), presented by the United States Coast and Geodetic Survey; and "*An Introduction to the Study of the Maya Hieroglyphs*," by S. G. Morley (Bulletin No. 57) (8vo., Washington, 1915), presented by the Bureau of American Ethnology, Washington.

Mr. D. THODAY, M.A., gave a demonstration of **Optical Properties of Chlorophyll.**

He began by referring to the importance of chlorophyll which enables green plants to utilise radiant energy from the sun in the synthesis of organic food substances from the carbon dioxide of the atmosphere. On this process the whole organic world, with few exceptions, directly or indirectly depends. A few classes of bacteria, *e.g.*, the iron and the sulphur bacteria, are independent of organic substances, making use of carbon dioxide in *chemosynthesis* by means of chemical energy, liberated in the oxidation of ferrous carbonate and sulphuretted hydrogen respectively. In the green plant the direct utilisation of sunlight in *photosynthesis* depends on chlorophyll, and this fact makes the optical properties of chlorophyll of especial interest.

Mr. Thoday then proceeded to demonstrate the red fluorescence of a chlorophyll solution, remarking that the sensitising action of this and other fluorescent pigments on photographic plates, and their toxicity to protozoa in extremely dilute solution only in the light, suggest that such pigments when exposed to light are especially active chemically. He then projected a spectrum and showed the absorption bands produced on interposing various thicknesses of chlorophyll solution, free from

xanthophylls and carotin. When the continuous spectrum was finally projected on to the chlorophyll solution the fluorescence was seen to be most marked in the neighbourhood of the chief absorption band in the red, but again very distinct towards the violet end, thus corresponding with the distribution of photosynthetic activity so far as this has yet been determined.

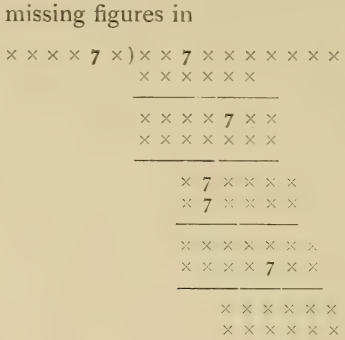
Dr. H. G. A. HICKLING, F.G.S., exhibited a series of plates and specimens illustrating the **variation in the colour of coal streaks** in accordance with the varying proportions of carbon in the coals, and also a number of samples of the fluorescent solutions obtained by washing finely ground coal-powder with benzine. He pointed out that the constituent of the coal dissolved by the benzine appears to be more especially characteristic of the bituminous or humic types of coal, little or no colour being obtained when the Cannel coals or anthracites are treated in the same way.

Ordinary Meeting, March 21st, 1916.

The President, Professor SYDNEY J. HICKSON, M.A., D.Sc., F.R.S., in the Chair.

A vote of thanks was accorded the donors of the books upon the table. These included:—"*Triangulation in West Virginia, Ohio, Kentucky, Indiana, Illinois, and Missouri*," by A. L. Baldwin (Special Publication No. 30) (4to., Washington, 1915), and "*Triangulation along the Columbia River and the Coasts of Oregon and Northern California*," by C. A. Mourhess (Special Publication No. 31) (4to., Washington, 1915), presented by the United States Coast and Geodetic Survey; and "*The Athenæum Subject Index to Periodicals, 1915. Theology and Philosophy*," (4to., London, 1916), presented by the Publishers.

Mr. C. L. BARNES, M.A., shewed an arithmetical problem, to find the missing figures in



The curious feature is that no figures are supplied except seven 7's. There are two methods of solving the problem, and two solutions are possible, viz., divisor 125473, dividend 73754284l3, quotient 58781 : or, divisor 125474, and the same quotient, with a corresponding change in the dividend.

The PRESIDENT recorded the re-occurrence of *Protohydra*, first discovered by Greeff, in 1868, at Ostend. Professor Hickson had recently received some material from the South of England which, on examination, revealed the presence of many living specimens of the animal. This marine form resembles the fresh-water *Hydra*, except that it has no tentacles, and is considerably smaller. The maximum length, extended, being 1·8 mm., and the diameter, contracted, about ·12 mm.

Professor F. E. WEISS, D.Sc., F.L.S. read a paper entitled **"Recent views concerning the nature of so-called 'Graft Hybrids'."**

Professor Weiss commenced by giving an account of the earliest authentic instances of what were considered by some botanists to be graft hybrids, beginning with the remarkable Bizzaria orange, which was discovered in Florence in 1644, and which had resulted from grafting a lemon on an orange stock. In this instance the resulting graft, instead of producing lemons, gave rise to branches bearing both oranges and lemons, and also to some fruits which were partly orange, partly lemon. Another

well-known graft hybrid, *Cytisus Adami* originated in 1825 by budding *Cytisus purpurens* on *Cytisus laburnum*, the yellow laburnum. In this case the main bud perished, but at its side an adventitious bud was formed and the shoot which developed from it bore foliage of a size intermediate between those of its parents. The inflorescence of this so-called purple laburnum was also intermediate in size, and the flowers in colour a mixture of yellow and purple. While in the case of this "graft hybrid" the majority of the branches bore foliage and flowers of the intermediate kind, known as *Cytisus Adami*, reversions to both the yellow Laburnum and the purple Cytisus are frequent, and, in some cases, even portions of a leaf or flower may revert to one of the parents.

Recently H. Winkler has produced a number of similar "hybrids" by grafting shoots of the tomato upon the black nightshade, and vice versa. When a firm union of stock and graft had taken place the plant was cut down to the region of the graft, and then numerous adventitious buds made their appearance from the region at which the two plants were united. In this way five distinct forms of shoots were obtained, all of them intermediate between stock and scion, but some leaning more to the tomato, others to the nightshade. Reversions to the two parents also commonly occur.

Macfarlane, in his careful description of *Cytisus Adami*, had already pointed out (1892) that this plant seemed to be "wrapped round by an epidermis of *Cytisus purpurens*" as its external features partook so closely to the nature of this latter species, and it is singularly noticeable that in most of Winkler's "graft hybrids" the outer layers showed a predominance of the characters of one of the parents. A closer examination has revealed in *Cytisus Adami* that the outermost layer of cells of all organs of the plant show in their most detailed characters all the features of the purple Cytisus, while the inner core of the plant seems to consist exclusively of cells of the yellow laburnum. Of Winkler's "hybrids" one seems to be covered by one layer of cells of the tomato, and another by two layers

of this plant, while two other forms are covered by one or by two layers respectively of the nightshade. As this apparent covering of one plant by a mantle of another differs essentially from the intimate intermingling of characters usually met with in seed hybrids, it has been suggested by Baur that the term "Chimaera" is more appropriate than "hybrid" for the curious growths resulting from special conditions in grafting. Baur also concluded that the so-called hybrid which has been obtained by grafting the medlar upon the hawthorn is probably also a "periclinal chimaera."

On the other hand one of Winkler's productions *Solanum Darwinianum* may be a true hybrid resulting from the intimate union of both plants probably with nuclear fusion, as seems likely from the number of its chromosomes.

Lucien Daniel has also described some intermediate forms resulting from the grafting of pear upon quince, and peach upon almond. In these cases as the intermediate shoot arose at some distance from the graft, in the former case on the roots of the quince, in the latter case upon the branches of the peach, it would seem that they cannot be chimaeras, more particularly as the intermediate characters are often found in deeply-seated parts as in the stone of the hybrid between almond and peach (*Amygdalo-persica*). In the hybrid between the pear and the quince (*Piro-cydonia*), one of the characters (hairiness) is also more strongly marked than in either of the parents.

It seems probable, therefore, that "graft hybrids" do not represent one form of vegetative union only, but that fusion of two different individuals can take place in more than one way.

Similarly in seed hybrids the characters of the parents may probably be associated with one another in a variety of ways.

Ordinary Meeting, April 4th, 1916.

The President, Professor SYDNEY J. HICKSON, M.A., D.Sc., F.R.S., in the Chair.

A vote of thanks was accorded the donors of the books upon the table. Amongst these were:—"*The Subantarctic Islands of New Zealand*," edited by Chas. Chilton, Vols. 1 and 2 (4to., Wellington, N.Z., 1909), and "*Index Faunæ Novæ Zealandiæ*," edited by F. W. Hutton (8vo., London, 1904), presented by the Philosophical Institute of Canterbury, Christ Church, N.Z.; and "*Latitude Observations with Photographic Zenith Tube at Gaithersburg, Md.*," by F. E. Ross (Special Publication No. 27) (4to., Washington, 1915), presented by the United States Coast and Geodetic Survey.

Professor G. ELLIOT SMITH, M.A., M.D., F.R.S., read a paper entitled **"The Origin of the Cerebral Cortex."**

The cerebral cortex was called into existence during the process of evolution of the vertebrates; and, even though it is difficult to detect it in certain fishes, it is to be regarded as a distinctive and inherent feature of vertebrate structure. The microscopic *formatio pallialis* of the Cyclostomes represents the undifferentiated rudiment of the whole of the pallium (hippocampal formation, piriform area and neopallium of the highest vertebrates), and not merely the hippocampus, as most modern anatomists believe. In this respect Professor Elliot Smith reaffirmed the views set forth by Studnička more than twenty years ago, and adversely criticised the divergent interpretations maintained respectively by Edinger and Ariens-Kappers and by Herrick, Johnstone and Sheldon on the other.

He discussed the nature of the factors which were responsible for calling into existence a cortical formation, citing the cerebellum as the simplest case, uncomplicated by the phenomena of consciousness, such as associative memory, feeling and discrimination. The cerebellum grew up around the central

terminations of the nerves which bring into the nervous system special information concerning the animal's position in space; and its cortical mechanism developed in response to the need for bringing this information under the control of other influences, such as the nerves of vision, touch and the muscular sense, &c., before it is transmitted to the muscles of the body as a whole, the activities of which it co-ordinates so as to make quick and nicely balanced responses possible.

The cerebral cortex grew up in a similar way around the central terminations of the olfactory nerve, which brings in to the central nervous system information of a more highly affective quality. It is a biological advantage for records of such experiences to be brought under the influence of other sensory impressions and be stored up so that they can be recalled in memory on future occasions. The cerebral cortex is the organ which develops to meet these requirements and so becomes the chief instrument of discrimination, not merely for impressions of smell but eventually for all the senses.

The same Author read a second paper entitled **"The Commencement of the Neolithic Phase of Culture."**

Although there is fairly complete agreement as to the facts relating to the phase of culture now commonly called "Azilian," there are still wide discrepancies as to the significance of the data. Because there is no evidence that the introducers of this culture into Europe brought every one of the practices which have somewhat arbitrarily been used to define the term "Neolithic," most archæologists have inclined to the opinion that the Azilian culture ought to be definitely excluded from the Neolithic, and regarded as a distinct Pre-Neolithic epoch; some writers (Professor H. F. Osborn, for example) even go so far as to include it in the Palæolithic.

Professor Elliot Smith maintained that the evidence pointed to the introducers of the Azilian culture as representing an early wave of the Neolithic people themselves, coming probably from Africa into Europe. He made the further suggestion that sporadic bearers of the same culture probably made their way into Europe

for many centuries before the close of the Palæolithic epoch there: this would explain many similarities not only of Magdalenian to Azilian implements, but also of both to those of Predynastic Egypt.

The question was raised whether the length of the Neolithic Period in western Europe had not been grossly exaggerated by many writers; and the possibility was suggested of the Magdalenian Period in the west being approximately contemporaneous with the Predynastic Period in Egypt, which would imply that the Neolithic Period in Europe did not begin before the third millenium B.C.

Mr. J. WILFRID JACKSON, F.G.S., read a paper entitled **"The Geographical Distribution of the use of Pearls and Pearl-shell."**

The same Author read a further paper entitled **"The Use of Shells for the Purposes of Currency."**

These two papers will be printed in full in the *Memoirs*.

Annual General Meeting, April 18th, 1916.

Mr. FRANCIS NICHOLSON, F.Z.S., Vice-President, in the Chair.

The Annual Report of the Council and the Statement of Accounts were presented, and it was resolved:—That the Annual Report, together with the Statement of Accounts, be adopted, and that they be printed in the Society's *Proceedings*.

Mr. ARTHUR ADAMSON and Mr. G. P. VARLEY were appointed Scrutineers of the balloting papers.

The following members were elected Officers of the Society and Members of the Council for the ensuing year:—

President: SYDNEY J. HICKSON, M.A., D.Sc., F.R.S.

Vice-Presidents: FRANCIS NICHOLSON, F.Z.S.; G. ELLIOT SMITH, M.A., M.D., F.R.S.; T. A. COWARD, F.Z.S., F.E.S.; W. W. HALDANE GEE, B.Sc., M.Sc.Tech., A.M.I.E.E.

Secretaries: R. L. TAYLOR, F.C.S., F.I.C.; GEORGE HICKLING, D.Sc., F.G.S.

Treasurer: W. HENRY TODD.

Librarian: C. L. BARNES, M.A.

Other Members of the Council: R. F. GWYTHER, M.A.; W. M. TATTERSALL, D.Sc.; FRANCIS JONES, M.Sc., F.R.S.E., F.C.S.; WILLIAM THOMSON, F.R.S.E., F.I.C., F.C.S.; MARY MCNICOL, M.Sc.; D. THODAY, M.A.

Ordinary Meeting, April 18th, 1916.

Mr. FRANCIS NICHOLSON, F.Z.S., Vice-President, in the Chair.

Professor W. BOYD DAWKINS, M.A., D.Sc., F.R.S., gave an address on **"The Lake Villagers of Glastonbury."**

The Lake Village of Glastonbury consisted of between 80 and 90 round huts surrounded by a stockade, and planted for security at the edge of the sheet of water, that is now represented by the peat in the marshes, extending from Glastonbury westward to the sea. The inhabitants smelted iron, and made various edged tools and weapons—axes, adzes, gouges, saws, sickles, bill-hooks, daggers, swords, spears, etc. They also smelted lead ore from the Mendip Hills, and made net-sinkers and spindle whorls. They probably carried on the manufacture of glass beads and rings, and other personal ornaments. They were also workers in tin and bronze. It is likely that the beautiful Glastonbury bowl was made in the settlement, since unused rivets of the same type as those of the bowl have been commonly met with. They were expert spinners and weavers, carpenters and potters, using the lathe at least in the former

industries. The discovery of a wooden wheel, with beautifully turned spokes, proves that they possessed wheeled vehicles while the snaffle-bits of iron imply the use of the horse. Their commerce was carried on partly by land, and the possession of canoes gave them the use of the water-ways. They were linked with other settlements by the road running due east from Glastonbury, that formed a part of the network of roads traversing the country in the Prehistoric Iron Age, and more especially with the lead-mines and the fortified oppida, or camps, of Mendip, and of the rest of the county.

They were also linked with the Bristol Channel by a waterway along the line of the river Brue, and along this was free communication with the oppidum of Worlebury, then inhabited by men of their race.

The Lake-villagers were undoubtedly in touch with their neighbours by sea and by land. Their jet probably came from Yorkshire; their Kimmeridge shale from Dorset; the amber from the eastern counties or from the amber coast south of the Baltic. The cocks for fighting were probably obtained from Gaul, and the oblong dice are identical with those used in Italy in Roman times. Some of the designs on their pottery are from the south, and the bronze mirrors are probably of Italo-Greek origin. The technique of the Glastonbury bowl is that of the goldsmiths of Mykenæ. The whole evidence points to a wide intercourse with the other British tribes, as well as to a commerce with those of the Continent, extending as far south as the highly-civilized peoples of the Mediterranean. It falls in line with that offered by other discoveries recorded in other parts of Britain, in settlements and tombs, by General Pitt-Rivers, Sir Arthur J. Evans, and others, proving that the inhabitants of Britain were highly civilized, and were not isolated from the higher Mediterranean culture, for some 200 years before the Roman Conquest.

We may infer from the absence of Roman remains that the Lake-village was abandoned before the influence of Rome was felt in Somerset.

All doubt, however, as to this point is removed by the recent explorations of Wookey Hole Cavern, where the group of objects in the Lake-villages was found in five well-defined layers underneath two superficial strata of Roman age, the latter being dated by the coins ranging from the time of Vespasian (A.D. 69-79) to Valentinian II. (A.D. 375-392). Here we have proof that the civilization of the Prehistoric Iron Age was pre-Roman, and that it ended in Somerset with the Roman Conquest. It has been traced in other parts of Britain as far back as 156 to 200 B.C.

The Lake-villagers were of pure Iberic stock, without admixture with other races. They belong to the small aborigines in Britain in the Neolithic Age, characterised by long or oval heads, who were conquered in the Bronze Age by the invading Goidels, and in the Prehistoric Iron Age by the invading Brythons, both of whom have left their mark in the topography of the district, by river names such as the Axe (Goidelic) and the Avon (Brythonic) = water; and hill names such as Dundry, Dun (Goid.) = fort; Mendips, Maen (Bryth.) = stone; Pen (Bryth.) = hill. From these it may be concluded that the language spoken by the Lake-villagers was closely allied to the Welsh. They were closely related to the Silures, the ruling tribe in South Wales at the time of the Roman Conquest.

The village was sacked, and, as the skulls on the table show, the inhabitants had been massacred, probably during the conquest of that region by the Belgic tribes, whose further progress was arrested by the Romans. This remarkable discovery is being followed up by the examination of another Lake-village at Meare, on the same water-way, belonging to the same pre-Roman age. The excavations are being described by Messrs. Arthur Bulleid, H. St. George Gray, and other workers ("The Glastonbury Lake Village," by Arthur Bulleid and H. St. George Gray.). The first volume was published in 1911, and the second is now nearly completed. When the whole story is told, by these and other contributors, it will fill a blank in the prehistory of Britain, and form a sound basis for history.

Ordinary Meeting, May 9th, 1916.

Professor W. W. HALDANE GEE, B.Sc., M.Sc.Tech., Vice-President, in the Chair.

Mr. C. L. BARNES, M.A., mentioned that sea-weed, now again in request as a source of iodine, was looked upon by the ancients as a type of worthlessness.

Thus Horace (Odes, III., 17) has

Cras foliis nemus
multis et alga litus inutili
demissa tempestas ab Euro sternet.

(To-morrow a storm, swooping down from the East, shall strew the grove with leaves and the shore with useless sea-weed.)

And in the *Satires*, II, v. 8, "Et genus et virtus nisi cum re vilior alga." (Birth and character without money are more worthless than sea-weed.)

Virgil (Eclogues, VII., 42) has "Horridior rusco proiecta vilior alga." (Rougher than broom, more worthless than unconsidered sea-weed.)

Rutilius, a minor poet of the 5th century, A.D., in describing a landlord's bill, says: "Vexatos frutices pulsatas imputat algas." (He charges for damaged shrubs and tumbled sea-weed.)

Lastly, in the *Tempest*, we read:

And, like the unsubstantial pageant faded,
Leave not a wrack behind.

The word "wrack" here, is akin to the French "varec," referring to the ashes of sea-weed, but also meaning "refuse" of any kind. "Wreck" is derived from the same root.

Mr. EDGAR NEWBERY, M.Sc., read a paper entitled: "**The Theory of Overvoltage.**"

Mr. R. F. GWYTHER, M.A., read a paper entitled, "**The Specification of Stress, Part IV.** (continued)."

These papers are printed in full in the *Memoirs*.

Ordinary Meeting, May 30th, 1916.

Professor W. W. HALDANE GEE, B.Sc., M.Sc.Tech., Vice-President, in the Chair.

A vote of thanks was accorded the donors of the books on the table. These included "*Transactions and Proceedings of the New Zealand Institute*," vols. 1—47 (8vo., Wellington, N.Z., 1869—1915), presented by Mr. Edward Melland.

Dr. W. H. R. RIVERS, M.D., F.R.S., read a paper entitled

"Irrigation and the Cultivation of Taro."

In the New Hebrides and New Caledonia irrigation is only used for the cultivation of *Colocasia antiquorum*, the taro of the Polynesians. This intimate connection between irrigation and taro, which is found in other parts of Oceania, suggests that if irrigation belongs to the megalithic culture (W. J. Perry, *Manchester Memoirs*, Vol. 60, Part I.), taro must have had a similar history. The distribution of the plant supports this suggestion, showing a close correspondence with that of the megalithic culture when its tropical and semi-tropical habits are taken into account. It occurs in Oceania, the Malay Archipelago, India and Eastern Asia, Arabia, Egypt, East and West Africa, the Canary Islands, Algeria, Southern Italy, Spain and Portugal, as well as tropical America. Since the original habitat of the plant is Southern Asia, its use as a food was probably acquired by the megalithic people in India and taken by them both to the east and west.

Although the general distribution of taro in Southern Melanesia corresponds with that of the megalithic influence, a difficulty is raised by the island of Malekula, in the new Hebrides. So far as we know, irrigation does not occur in this island, although megalithic influence is present in a very definite form. To account for the absence of irrigation in this island, it is shown that modes of disposal of the dead point to two megalithic intrusions into Oceania, and the high degree of development of irrigation in such outlying islands and districts as New Caledonia, Anaiteum and North-Western Santo in Melanesia

and the Marquesa and Paumotu Islands in Polynesia suggests that this practice belonged to the earlier of the two movements. There is reason to believe that this movement had relatively little influence in Malekula.

Professor G. ELLIOT SMITH, M.A., M.D., F.R.S., read a paper entitled "**The Arrival of *Homo sapiens* in Europe.**"

At a time when little was known of early man and his works beyond the stone implements which he fashioned, Sir John Lubbock (afterwards Lord Avebury) suggested the use of the terms Palæolithic and Neolithic to distinguish respectively between the earlier part of the Stone Age, when crudely worked implements were made, and the later period, when more carefully finished workmanship was shown. In spite of the fact that subsequent investigation revealed a high degree of skill in the craftsmanship of the Upper Palæolithic period, which in many respects shows a very much closer affinity to the Neolithic than to the Lower Palæolithic period, Lubbock's terminology has become so firmly established that it has continued to determine the primary subdivision into epochs of the early history of man.

Recent research has brought to light a vast amount of new information relating to the achievements of Upper Palæolithic man, and has conclusively shown that human culture and artistic expression had already attained the distinctive characters which mark them as the efforts of men like ourselves. This view has been amply confirmed by the general recognition of the fact that, after the disappearance of Neanderthal man at the end of the Monsterian period, the new race of men that supplanted them in Europe and introduced the Aurignacian culture conform in all essential respects to our own specific type—*Homo sapiens*.

Thus the facts of physical structure, no less than the artistic abilities and the craftsmanship, of the men of the Upper Palæolithic proclaim their affinity with ourselves. The earlier types of mankind which invaded Europe and left their remains near Piltdown, Heidelberg, and in the various Monsterian stations

belong to divergent species, and perhaps genera, which can be grouped together as belonging to a *Palæanthropic Age*, which gave place (at the end of the Monsterian epoch in Europe) to a *Neoanthropic Age*, when men of the modern type, with higher skill and definite powers of artistic expression, made their appearance and supplanted their predecessors.

So long as primary importance continues to be assigned to the terms Palæolithic and Neolithic the perspective of anthropology will be distorted.

Though the facts I have enumerated in this communication are widely recognised, one finds that the writers who frankly admit them lapse from time to time into the mode of thought necessarily involved in the use of the terms Palæolithic and Neolithic. If modern ideas are to find their just and unbiassed expression some such new terminology as is suggested here becomes necessary.

MANCHESTER

LITERARY AND PHILOSOPHICAL SOCIETY.

Annual Report of the Council, April, 1916.

The Society had at the beginning of the session an ordinary membership of 140. Since then eight new members have joined the Society, nine members have resigned, and one member, Mr. W. H. Core, M.Sc., has died. There are, therefore, at the end of the session, 138 ordinary members of the Society. The Society has also lost, by death, four honorary members, viz.: Dr. H. Debus, F.R.S., The Right Hon. Sir Henry E. Roscoe, D.C.L., LL.D., F.R.S., Professor Graf zu Solms Laubach, For. Mem. R.S., and Professor Sir William Turner, K.C.B., M.B., D.C.L., F.R.S. Memorial notices of these gentlemen will appear with this report in the *Memoirs and Proceedings.*

Twenty-six papers have been read at the meetings during the year; fourteen shorter communications have also been made.

The Society commenced the session with a balance in hand, from all sources, of £462. 1s. 1½d., made up as follows:—

At credit of General Fund	£24	2	2½
„ „ Wilde Endowment Fund...	353	4	5
„ „ Joule Memorial Fund.....	84	14	6
Balance 31st March, 1915.....	£462	1	1½

The balance in hand at the close of the session amounted to £329. 8s. 4d., the amounts standing at credit of the various accounts on the 31st March, 1916, being:—

At credit of General Fund.....	£	27	19 1
„ „ Wilde Endowment Fund...	224	12	0
„ „ Joule Memorial Fund	76	17	3
Balance 31st March, 1916.....	£329	8	4

The Wilde Endowment Fund, kept as a separate banking account, shows a balance due to the Fund of £224 12s. 0d. in its favour, as against a balance in hand of £353. 4s. 5d. at the end of the last financial year. The receipts for the year 1915-16 show a slight decrease as compared with those for the previous year.

£195. 16s. 0d. of the balance of the Wilde Endowment Fund has been invested in the purchase of £200 of the new 4½ per cent. War Loan Stock; and the £200 (£188. 17s. 3d.) of the 3½ per cent. War Loan Stock purchased last year for the Joule Memorial Fund has been converted into £200 of the new 4½ per cent. War Loan Stock.

The Society's house has been insured under the Government Air Raid insurance scheme.

The Librarian reports that during the session 672 volumes have been stamped, catalogued and pressmarked; 611 of these were serials, and 61 were separate works. 229 catalogue cards were written, 149 for serials, and 80 for separate works. The total number of volumes catalogued to date is 37,039 for which 12,876 cards have been written.

The library continues to be satisfactorily used for reference purposes. 184 volumes have been borrowed from the library

during the past year. The number of books borrowed during the previous year was 201, and during 1912-13, 285.

During the year 220 volumes have been bound in 163 covers. In the previous session the corresponding numbers were 288 volumes in 194 covers.

The additions to the library for the session amounted to 687 volumes, 622 serials, and 65 separate works. The donations (exclusive of the usual exchanges) were 60 volumes; 5 volumes were purchased, in addition to those regularly subscribed for.

The Society's publications are now forwarded to the Editor of *The Athenæum* for the new Subject Index to periodicals published for the Council of the Library Association.

Certain of the medical books in the library have been offered to the Manchester Medical Society and accepted by them.

The 4th series of the *Royal Society's Catalogue of Scientific Papers* (1884-1900) is being subscribed to, and volumes 18, part I., and 26 of *Archæologia* have also been purchased.

The donations to the Society's Library during the session include gifts of books by the Trustees of the British Museum (Natural History), the Royal Observatory, Greenwich, the Meteorological Office, London, Mr. T. A. Coward, Mr. Francis Nicholson, and Miss Laura Start.

The publication of the Society's *Memoirs and Proceedings* has been continued under the supervision of the Editorial Committee.

An agreement with the Manchester University Press dealing with the sale of the Society's *Memoirs and Proceedings* is at present under consideration.

The Society is indebted to Mr. Francis Jones for defraying the expense of framing Dalton's pedigree, and to Mr. Francis Nicholson for the cost of renovating Dalton's silver inkstand.

A case has been provided for the Dalton Diagrams, and a *Memoir* dealing with these is now on sale.

During the meeting of the British Association in September, an Exhibition of Apparatus, Portraits, Books, etc., of historical interest was arranged in the Society's House and opened to members of the Association on the afternoons of Wednesday, Thursday and Friday, the 8th, 9th and 10th of September. Members of Sections A and G. (Mathematical and Physical Sciences and Engineering) were invited on Wednesday; Members of Section B (Chemistry) on Thursday; and Members of Sections C, D, H, I and K (Geology, Zoology, Anthropology, Physiology and Botany) on Friday. A short account of the Society's House, with a list of the exhibits was prepared and distributed to the visitors. This is also published in the *Proceedings*.

Mr. and Mrs. R. Kelly having resigned their posts as Caretaker and Housekeeper to the Society, the Council have appointed Mr. and Mrs. J. Bruce to fill these positions.

The Committees appointed by the Council during the year were as follows:—

House and Finance.

The President.
Mr. C. L. Barnes.
Mr. Francis Jones.
Mr. R. L. Taylor.
Mr. Francis Nicholson.
Mr. W. H. Todd.
Dr. H. G. A. Hickling.

Editorial.

The President.
Mr. R. F. Gwyther.
Dr. H. G. A. Hickling.
Mr. Francis Nicholson.
Mr. R. L. Taylor.
The Assistant Secretary.

Wilde Endowment.

The PRESIDENT.
Mr. FRANCIS JONES.
Dr. H. G. A. HICKLING.
Mr. W. H. TODD.
Mr. R. L. TAYLOR.

Special Library Committee.

The PRESIDENT.
Mr. C. L. BARNES.
Professor W. W. HALDANE GEE.
Mr. R. L. TAYLOR.
Mr. FRANCIS NICHOLSON.
Mr. R. F. GWYTHER.
Mr. FRANCIS JONES.
Dr. H. G. A. HICKLING.
The ASSISTANT SECRETARY.

British Association Committee.

The PRESIDENT.
Mr. C. L. BARNES.
Mr. FRANCIS JONES.
Dr. H. G. A. HICKLING.
Mr. FRANCIS NICHOLSON.
Professor W. W. HALDANE GEE.
Mr. R. L. TAYLOR.

Publications Committee.

The PRESIDENT.
Dr. W. M. TATTERSALL.
Mr. C. L. BARNES
Dr. H. G. A. HICKLING.

Dr. Debus, F.R.S.—By the death of Dr. Heinrich Debus, chemical science loses an able investigator and the Society one of its oldest honorary members. He was born in Hessen in 1824 so that he had reached the advanced age of 91 when he died on December 9th, 1915. Dr. Debus studied chemistry under Bunsen at the Polytechnic School at Cassel and followed him to Marburg There he met Kolbe and Frankland, with whom he became very intimate, and there he investigated the chemistry of madder which formed the subject of his first paper, published in 1848. In 1851 he came to England and taught Chemistry at Queenwood College, Hampshire, and later at Clifton College. He left Clifton in 1870 on his appointment as lecturer on Chemistry at Guy's Hospital, where he remained till elected first professor of Chemistry in the newly established Naval College at Greenwich. This was his last appointment and when he resigned it he returned to Germany.

Dr. Debus was a voluminous writer and communicated many papers on a great variety of subjects to the scientific journals. Perhaps his most important papers were those on the chemical theory of gunpowder and on the oxidation products of ethyl alcohol, glycol, and glycerine. He showed that the action of nitric acid on alcohol yielded acetic, formic, oxalic and glycollic acids, and in addition a new acid which he named glyoxylic acid. After the discovery of glycol by Wurtz in 1859 he showed that this new body also yielded glyoxylic acid on oxidation.

Dr. Debus joined the Chemical Society in 1859 and later became a Vice-President. He was elected a Fellow of the Royal Society in 1861.

To a wide knowledge of chemistry Dr. Debus added a deep interest in other scientific subjects. He was an excellent teacher and had the faculty for interesting his students by whom he was greatly esteemed. He never married and outlived nearly all his scientific contemporaries, but will be remembered in the annals of chemistry for the important additions he made to the progress of that science. F. J.

Henry Enfield Roscoe, the son of Henry Roscoe, a barrister, of Liverpool, was born in London in 1833. He was the grandson of William Roscoe, a banker in Liverpool, well known as the author of the *Life of Lorenzo de' Medici.* Roscoe's mother was the daughter of a Liverpool merchant named Fletcher and the granddaughter of Dr. William Enfield, Rector of Warrington Academy, where Joseph Priestley taught chemistry. He was educated at the Liverpool Institute, and was taught chemistry by W. H. Balmain, the inventor of "luminous paint." His education was continued at University College, London, where he came under the influence of Thomas Graham, and subsequently of A. W. Williamson, who succeeded Graham in the chair of chemistry. Leaving London he proceeded to Heidelberg to study under Bunsen, and there began a life-long friendship and a close association in scientific investigation with that eminent chemist. After taking his degree, Roscoe joined Bunsen in a prolonged research on the chemical intensity of light and on a method for determining its amount. Their first method was founded on the well-known fact that chlorine and hydrogen when mixed together and exposed to light, combined together, with formation of hydrochloric acid easily soluble in water. The apparatus used for this investigation served to prove several points of great interest among others, that the amount of chemical action occurring from a constant source, varied inversely as the square of the distance. By means of it they also showed the effect of the different parts of the spectrum on the rate of combination of the two gases. Their second method depended on the observation of the amount of darkening occurring in specially prepared photographic paper and comparing it after exposure to light with standard tints. The apparatus required for this purpose was simpler and more portable than that of the first method and much more generally applicable. More than seven years were occupied in this research, the results of which are recorded in the *Philosophical Transactions.*

Leaving Heidelberg, Roscoe settled in London and established a private laboratory, having Wilhelm Dittmar as his

assistant. Here they worked on the absorption of hydrochloric acid and ammonia in water and later on the effect of heat on solutions of the volatile acids. They ascertained that strong and weak solutions of such acids when boiled, each leave a residue of definite composition depending on the pressure at which the boiling took place.

In 1857 Roscoe was elected as Frankland's successor in the chair of chemistry in Owens College, Manchester, at the early age of twenty-four. Here he was soon occupied in a research on perchloric acid and its hydrates and salts, and with Thorpe's assistance he was able to show that thallium perchlorate was isomorphous with the perchlorates of potassium and ammonium.

But the chief research with which Roscoe's name will always be associated was his investigation of the rare metal vanadium and its compounds. In 1865 copper was being obtained at Alderley Edge and the waste products were found to yield a blue solution which did not give the reactions for copper salts. This was brought to Roscoe's notice and it was soon recognised that it contained vanadium. Such an opportunity for studying the metal was not to be lost, and very soon the whole of the waste product was transferred to the cellars of the old Owens College in Quay Street. Many difficulties were encountered in obtaining pure vanadium compounds from this source, but they were eventually overcome and the purified products were used for an elaborate research. The chief results obtained need only be briefly referred to. It was shown that the atomic weight of vanadium estimated by Berzelius as 68·5 was incorrect and the true value 51·3. The Swedish chemist had prepared the oxychloride, but considered it the trichloride, and based his calculations on that erroneous assumption. Roscoe showed that the volatile liquid was really an oxychloride like phosphorus oxychloride and that the element belonged to the phosphorus-arsenic group. The metal itself had not been previously obtained but was prepared by the reduction of the dichloride in a current of hydrogen.

It remains to mention the titles of other communications made to the Royal and chemical societies after the vanadium research was completed: "On a new chloride of Uranium," "Note on the Specific Gravity of the vapour of the chlorides of Thallium and Lead," "A study of some of the Earth-metals contained in Samarskite," and in conjunction with Professor Schuster papers on the Spectrum of Terbium and on the Absorption-spectra of Potassium and Sodium.

Soon after Roscoe's election to the chair of chemistry in Owens College he became a member of this Society. His connection with it was long and intimate. He became joint secretary with Dr. E. Schunck in 1860 and then, with Mr. Baxendell, remained secretary till 1873. Three years later he became Vice-President and in 1882 was elected President of the Society. During his long membership Roscoe contributed many papers to our *Memoirs*, the titles of which will be found below.

Roscoe's scientific eminence and his great work in connection with education brought him many honours both in this country and abroad. He was elected President of the British Association in 1887 and to the Vice-Chancellorship of the University of London in 1896. He had received the honour of Knighthood in 1884 and in 1909 was sworn of the Privy Council.

He died, somewhat suddenly, on December 18th, 1915, at the age of 82.

Papers read before the Society:

"On the alleged practice of Arsenic Eating in Styria." (1860).

"The existence of a crystallizable carbon compound and free sulphur in the Alais Meteorite." (1863).

"Note on the amount of carbonic acid contained in the air of Manchester." (1864).

"On the isomorphism of thallium-perchlorate with the potassium and ammonium-perchlorates." (1866).

"On the properties of vanadium." [Title only.] (1868).

"On measurements of the chemical intensity of total daylight made during the recent total eclipse of the sun, by Lieut. J. Herschel, R.E." (1868).

"A study of certain Tungsten compounds." (1872).

"On the corrosion of leaden hot-water cisterns." (1874).

"Some remarks on Dalton's first table of atomic weights." (1874).

"Notes on a collection of apparatus employed by Dr. Dalton in his researches, which is about to be exhibited (by the Council of the Literary and Philosophical Society of Manchester) at the Loan Exhibition of Scientific Apparatus at South Kensington." (1876).

"Note on metallic niobium and a new niobium chloride." (1877).

"On a new variety of Halloysite from Maidenpete, Servia." (1884).

"On the diamond-bearing rocks of South Africa." (1884).

There were also several minor communications.

F. J.

While gladly complying with the request that I should add to the preceding notice of the scientific work of the late Sir Henry Roscoe, and of the part taken by him in the proceedings of the Manchester Literary and Philosophical Society, a few words concerning his general services to education, I must confess to an initial difficulty in making such an attempt. As Roscoe himself, in his *Autobiography*, says of Pasteur, the great benefactor of suffering humanity, for whom, next to Bunsen, the "guide, philosopher and friend" of his early manhood, he cherished, perhaps, the most thorough personal admiration, he began and ended as a chemist. It was his faithful devotion to the science to which he had at an early date, with what at the time was no slight proof of moral courage, elected to give up his life, which lay at the root of his success as a teacher. And, since he had soon come to see that chemistry cannot be rightly taught as an isolated science, his fidelity to his chosen study aroused in him an interest in scientific teaching in general, and, with it, in higher and in secondary, including technical education, of

which he had come to the conclusion that scientific instruction should form an integral part. Can this stage in the evolution of Roscoe's educational work be profitably discussed by one whose insight into its initial stages must, for the most obvious of reasons, be at fault? On the other hand, inasmuch as we stood side by side during more than two-thirds of the part of his life which he spent at Manchester as a professor at Owens College and the Victoria University, I feel able to bear witness to something more than the success which attended his unwearying labours among us. Without him, the college in Quay Street would not have averted the humiliating collapse which was threatening it at the time of his arrival; without him, it would not have developed into what it had become when it vindicated to itself recognition as the single college of a national university. The main reason of this growth can be stated in the briefest of ways: it lay in the fact that Roscoe's chemical laboratory had become the foremost in this country. Its advance to this position had been consciously planned by him. Much of the secret he had learned from Bunsen at Heidelberg—more was due to his own genius as a teacher, organiser and administrator. He refers in his *Autobiography*, rather perfunctorily perhaps, to the oft-debated question of the tutorial *versus* the professorial system of teaching; but it is quite certain that the chief advantages of both were combined in his own method as a teacher—pursued as it was from the one point of view of the advancement of learning by the inculcation and experimental illustration of scientific principles as well as by the encouragement of steadfast individual labour in the search after wholly or partially hidden natural truths. Class-room and laboratory thus supplement each other; and original research—a term with which, notwithstanding its rather hackneyed use, we cannot afford to dispense—becomes the cause of scientific education.

Inspired by the examples of Dalton and Joule, and with Frankland as his predecessor in his professorial chair, Roscoe became the real founder of the Manchester School of Chemistry. Into what kind of school it grew, is shown by the distinguished list

of his demonstrators and assistant-lecturers, beginning (or nearly so) with Dittmar and Schorlemmer, who afterwards, at Roscoe's suggestion, was appointed Professor of Organic Chemistry, and contributed the volume on that branch of the science to their joint *magnum opus*, and including Thorpe, Smithells, and many younger men. Sir Edward Thorpe, who for a number of years was, in more ways than one, his chief's *alter ego*, has, quite recently, enlarged the obituary notice written by him for the Transactions of the Royal and Chemical Societies, into a most readable as well as instructive biography of his honoured friend. Still larger, of course, is the list of students in his classes who have made a name for themselves as men of science; but it may be doubted whether there is one of them who would not regard Roscoe's encouragement of research as the most effective element in his guidance. A far more multitudinous body of learners were taught to understand something of his gifts as an instructor, apart from his manipulative ability as an experimenter, by means of that clearness of exposition and inborn dislike of the superfluous which his manuals attest—the *Elementary Chemistry*, with its 2–300,000, and the *Chemistry Primer*, with its 3–400,000 printed copies, which have taught generations of undergraduates and schoolboys the rudiments of his science. The same qualities, added to the sympathetic charm of a genial and absolutely unaffected manner, account for the unfailing success of his popular lectures of various sorts and kinds. At the Royal Instituion, where the audiences at least know something of the art of lecturing, he made his first appearance at the age of twenty-three; but his success was most striking in the Science Lectures for the People, which sprang from the high-minded and warm-hearted conception of a series of addresses to unemployed operatives at the time of the Cotton Famine of 1862, which may be said to have been, for many years afterwards, a standing feature of Lancashire life.

Roscoe's association with Manchester was, it has been said, so enduring that its character only changed—and was then far from entirely—after his election to Parliament as member for

one of the divisions of the borough. His motives for this relinquishment of his academical work were of a purely personal, but wholly unselfish, nature, and implied no diminution of his attachment to the University of which he had been the principal founder. Several years earlier, he had been in vain tempted to transfer his services to Oxford, and again to the foremost of the great London Medical Schools; as to Oxford, whose relations with Manchester in connection with the teaching of his science have consisted in a continuous profitable system of give and take, he, after some hesitation, made up his mind with that simple straightforwardness which, fortunately for the institu ions and causes with which he was brought into contact, was part of his nature: 'I felt that I had a wider scope and more useful life in building up the Chemical School of the Owens College.'

The 'Extension Movement' of 1870, and the foundation of the Victoria University, accomplished by the grant of the Royal Charter in 1880, were the two occasions on which the paramount position of Roscoe in Manchester's academical, as connected with its industrial and general life, was most notably displayed. The former movement, of which its successor, ten years afterwards, may be regarded as the natural outcome, was what the Germans, in the days when they still used to envy British enterprise, would have called a 'practical' effort, and needed for its execution a man practical in the fullest sense of the word. Him Roscoe found in the late Thomas Ashton, in his generation a man of leading, if ever there was such in the public life of a great community. The more complex undertaking which was to crown the result thus achieved, by the recognition as a national University of a College which had come to do university work in the centre of the busiest part of the kingdom, was first suggested to Roscoe by Lord Kelvin, himself one of the glories of Glasgow and of Cambridge alike. In the preliminary struggle which ensued—for there was a good deal of hard hitting on the adverse side, with Mr. Robert Lowe (Lord Sherbrooke) in the van—many took part: none more usefully than the Principal of the Owens College, the late Dr.

Greenwood. To him it was largely due, that, as in the extension of the College, so in the design of converting it into a University, full regard was had to the preservation of a fair balance between the great divisions of learning, which proved attainable even without insisting on compulsory Greek and Latin for its degrees. But it was Roscoe's knowledge of men and things which facilitated every step of the progress towards the desired end. Nor was the basis of compromise, on which a federal university was in the first instance called into life, in lieu of the municipal which had been originally intended, wholly unwelcome to his width and freedom of judgment—more especially in view of the certainty that the adoption, for the time at all events, of the federal system must lead to an advance in other great commercial and industrial centres besides Manchester itself. The real drawback in the victory gained lay elsewhere, though it was not unconnected with the causes which had brought about the change of design; but no one could doubt that the new University would not long be left without the power, denied to it at first, of granting medical degrees. At the time, however, Roscoe greatly resented this 'emasculation,' as he called it, of the University curriculum; for, as his later correspondence with Mr. Balfour showed, he attached the highest importance to a sound basis of the teaching of science to medical students.

More cannot be said here of these important transactions, the significance of which for the progress of higher education, and through it, in some measure, for that of secondary education, also, in England, is now universally acknowledged. On the advance of a particular kind of instruction, which long hovered half-way between the one and the other, he likewise set his personal mark after, in 1881, he had become a member of the Royal Commission on Technical Instruction. (The first occasion on which he had been called upon to give his services in the same capacity had, characteristically, been that of a purely scientific enquiry: Lord Aberdare's Noxious Vapours Commission of 1876, which led to the passing, not more than fifteen years later, of the first of the Alkalis Acts.) Few Commissioners'

reports have had a more direct influence alike on educational and on industrial progress than that presented by Roscoe and his colleagues after their enquiry into technical instruction and its effect upon industries abroad. Though his own legislative attempts for the application at home of these experiences were unsuccessful, while the Technical Schools' Act of 1889 was not altogether in conformity with his own views on the subject, the cause of which he was one of the most eminent advocates in 1890 derived a great moral as well as material advantage from the spirited appropriation by the late Lord Goschen of the 'whisky money' to the purposes of technical and secondary education; and the great Education Act of 1902, though it repealed the Technical Instruction Act of 1889, gave a far more comprehensive range to the principle of this appropriation; and, in the end, Roscoe had the satisfaction of witnessing the adoption in this country of the principle strenuously urged by him in contravention of the practice preferred in Germany, of co-ordinating the highest technological training with instruction in arts and science. Many of us, it must be confessed, long 'fought shy' of this principle; but Manchester University has, not too soon, become a convert to it. May the remark be added that for effective results from this system much depends on the right sequence between practical and University work, consistently advocated by Sir William Mather?

Roscoe's labours as a member of the Royal Commission on Secondary Education and of the Scottish University Commission must here be passed by; but those who have followed them are aware of the consistency with which he asserted for original research its place in higher, and for training to that end in Secondary, Education—the latter even in the neighbourhood of the playing-fields of Eton College, of which he was for many years a Governor. When, at a later date, he became one of the Carnegie Trustees, it was in the same direction that he successfully exerted his influence. During all these years, both while he held a seat in Parliament and afterwards, his advice as a practical chemist was eagerly sought by the House of Commons

itself, by the Metropolitan Board of Works and by the authorities of the Mersey and Irwell Watershed, who were fain that their rivers should be made pure even as Father Thames had been. Roscoe's design of a National Water (Supply) Board remains a vision of the future. Of his effective interest in the all-important subject of Preventive Medicine I have already spoken.

In 1896, he became Vice-Chancellor of the University of London, and during six years presided with his usual ability and success over the deliberations of the rulers of that body, which, notwithstanding the great work already done by it for the nation, seemed to be as it were perpetually *im Werden*. He had to superintend the reconstruction of the University, after the report of two Royal Commissions, as a teaching body—the development which, of all others, he had at heart, but the accomplishment of which affected the interests of a number of other institutions in and out of London, as well as of the constituent Colleges; while its important and time-honoured examining functions continued. He had to preside over the appointment of a new and complex Governing Body and of a practically new administrative staff. And he had to carry through the decision on the thorny question of the University's new local habitation. Fortunately for himself and the University, he had, in most of these matters, the counsel and assistance of the first occupant of the newly-created office of Principal, the late Sir Arthur Rücker, to whom, as to his successor, now our Vice-Chancellor at Manchester, our elder sister at London owes a very great debt. Roscoe's six years of office were thus far from being years of dignified leisure, and his name will be gratefully remembered among those of the re-founders of the great institution which had developed out of the college that had been the *Alma Mater* of his youth. Yet when, in 1904, the crowning hour of his long life and indefatigable labours was paid to him by his pupils, colleagues and friends from all over the world, it was characteristic of him and of the loyalty which ennobled the conduct of his life that he should have chosen Manchester for the scene of the homage offered to him, and that it was his Heidelberg

doctorate of which he thus celebrated the jubilee. If it is impossible to look without a wondering admiration upon the labours of his fourscore years, the goodwill towards men which inspired them formed an essential part of his conception of the true man of science. A. W. W.

Count Solms-Laubach.—By the death, in November of last year, of Hermann Graf zu Solms-Laubach, botanical science has lost one of its most distinguished members. Though a descendant of one of the most ancient branches of German aristocracy, Count Solms was always one of the most unassuming of men, and his unvarying kindliness endeared him to a large circle of botanists both in his own country and in Britain.

He was born in 1842, and after studying in the Universities of Berlin, Giessen and Freiburg, he commenced his work as a teacher in the University of Halle in 1868, and was subsequently appointed Professor in the University of Göttingen (1879). In 1888 he succeeded De Bary as Professor in the University of Strasburg, where he remained until his retirement a few years ago.

His knowledge of botany was as extensive as it was thorough. His early investigations were devoted to the study of the structure and nutrition of various groups of parasitic plants, to the knowledge of which he made substantial contributions. He was also interested in cultivated plants, and published some important memoirs on the fig, the papaw, wheat and strawberries. Of his purely systematic works, the monograph of the Acetabulariaceæ, published in 1895 in the Transactions of the Linnean Society of London, is probably the most important, and of particular interest to us as being written in English. In 1905 he published a book on somewhat new lines on the "Principles of Plant Geography." Probably, however, Count Solms' name will, in this country at any rate, be most closely associated with his "Introduction to Palaeophytology," which was issued in German in 1887 and subsequently in English by the Clarendon Press in 1892. This book not only reveals his encyclopaedic

knowledge of the literature of the subject upon which he was at work, but also his profound appreciation of the importance of the new work which was being done in his branch of science in this country, particularly by Professor Williamson. Solms himself published many important papers on palaeobotanical subjects, and retained to the end a great interest in fossil plants.

For many years he was editor, first in conjunction with Wortmann and then with Oltmanns, of the "Botanische Zeitung." He was elected a foreign member of the Linnean Society in 1887 and was awarded the gold medal of the Linnean Society in 1911. He was elected honorary member of our Society in 1892 and in 1906 foreign member of the Royal Society. In addition, he was a member of a large number of learned societies both in Germany and in other countries.

Count Solms visited England on repeated occasions, often attending the meetings of the British Association, as he did in Manchester in 1887 as a friend of the late Professor Williamson. He was personally known to many British botanists, all of whom cordially appreciated the many expressions of his friendship. By his death the scientific world has lost a singularly impressive and picturesque figure, and his botanical colleagues a friend of great personal charm. F. E. W.

MANCHESTER LITERARY A

Dr. *W. Henry Todd, Treasurer, in Account with*

	£ s. d.	£
To Balance, 1st April, 1915		198 1
To Members' Subscriptions :—		
Half Subscriptions, 1909-10, 1 at £1. 1s. od.	1 1 0	
,, 1910-11, 1 ,, ,, ...	1 1 0	
,, 1911-12, 1 ,, ,, ...	1 1 0	
,, 1912-13, 1 ,, ,, ...	1 1 0	
,, 1913-14, 2 ,, ,, ...	2 2 0	
,, 1914-15, 4 ,, ,, ...	4 4 0	
,, 1915-16, 8 ,, ,, ...	8 8 0	
Subscriptions :— 1911-12, 1 ,, £2. 2s. od.	2 2 0	
,, 1912-13, 1 ,, ,, ...	2 2 0	
,, 1913-14, 3 ,, ,, ...	6 6 0	
,, 1914-15, 11 ,, ,, ...	23 2 0	
,, 1915-16, 96 ,, ,, ...	201 12 0	
		254
To Transfers from the Wilde Endowment Fund	.. ..	53 1
To Sale of Publications	.. ..	19
To Sale of Publications to Manchester University Press	.. ..	12 1
To Sale of Catalogue	.. ..	0
To Sale of Blocks to Manchester Corporation	.. ..	0
To Dividends :—		
Natural History Fund	53 1 8	
Joule Memorial Fund	11 17 8	
Wilde Endowment Fund	3 16 6	
		68 1
To Income Tax Refunded :—		
Natural History Fund	6 1 3	
Joule Memorial Fund	1 1 5	
Wilde Endowment Fund	32 16 4	
		39
To National Health Insurance Act deductions	.. ..	2
		£590

NATURAL HISTO

	£
To Dividends on £1,225 Great Western Railway Company's Stock	53
To Remission of Income Tax, 1915	0
	£50

JOULE MEMOR

	£
To Balance, 1st April, 1915	84
To Dividends on £100 East India Railway Company's 4 % Annuity Stock	5
To Interest on £200 War Loan	7
To Remission of Income Tax, 1915	1
	£97

WILDE ENDOWME

	£
To Balance, 1st April, 1915	353
To Dividends on £7,500 Gas Light and Coke Company's Ordinary Stock	277
To Interest on £200 War Loan	3
To Remission of Income Tax, 1915	3
To Bank Interest	1
	£66

ILOSOPHICAL SOCIETY.

ety, from 1st April, 1915, to 31st March, 1916. **Cr.**

	£ s. d.	£ s. d.
Charges on Property :—		
Chief Rent (Income Tax deducted)	11 4 0	
Income Tax	1 18 8	
Insurance against Fire	11 0 0	
Insurance against Air Raids	11 10 0	
House Expenditure :—		35 12 8
Coals, Gas, Electric Light, Water, &c.	36 10 6½	
Tea, Coffee, &c., at Meetings	19 18 0	
Cleaning, Sweeping Chimneys, &c.	4 9 2½	
Replacements of mantles, crockery, dusters, ironware, etc.	6 12 7½	
Whitewashing, repairs, etc.	4 10 6	
Cleaning Carpets	8 12 0	
Administrative Charges :—		80 12 10½
Housekeeper	66 5 0	
Postages, and Carriage of Parcels and of "Memoirs"	46 5 6	
Stationery, Cheques, Receipts, and Engrossing	6 17 5	
Printing Circulars, Reports, Articles of Association, &c.	5 11 6	
Extra attendance at Meetings, and during housekeeper's holidays	6 3 0	
Insurance against Liability	0 12 0	
National Health Insurance Stamps	4 8 4	
Miscellaneous Expenses	3 15 7½	
		139 18 4½
Renovation of Dalton Apparatus	.. ..	2 7 6
Framing Dalton MSS.	.. ..	1 16 3
Publishing :—		
Printing "Memoirs and Proceedings"	116 12 0	
Illustrations for "Memoirs" (except Nat. Hist. papers)	9 11 3	
		126 3 3
Library :—		
Books and Periodicals (except those charged to Natural History Fund)	15 5 3	
Periodicals formerly subscribed for by the Microscopical and Natural History Section	3 7 6	
		18 12 9
Natural History Fund :—		
(Items shown in the Balance Sheet of this Fund below)	.. ..	22 12 9
Joule Memorial Fund :—		
(Items shown in the Balance Sheet of this Fund below)	.. ..	20 16 4
Wilde Endowment Fund (Income Tax refunded)	.. ..	32 16 4
,, ,, ,, (Dividend refunded)	.. ..	3 16 6
Balance at Williams Deacon's Bank, 1st April, 1916	94 16 4	
,, in Treasurer's hands	10 0 0	
		104 16 4
		£500 1 11

JND, 1915—1916. (Included in the General Account, above.)

	£ s. d.
Balance against this Fund, 1st April, 1915	17 5 1
Natural History Periodicals	18 4 9
Illustrations for papers on Nat. Hist. in "Memoirs"	1 18 0
Binding Periodicals	2 10 0
Balance, 1st April, 1916	19 5 1
	£50 2 11

JND, 1915—1916. (Included in the General Account, above.)

	£ s. d.
Conversion of £200 War Loan to 4½ % Stock	10 0 0
Expenses of Conversion of Stock	0 6 4
Special Lecture	10 10 0
Balance, 1st April, 1916	76 17 3
	£97 13 7

JND, 1915—1916.

	£ s. d.
Assistant Secretary's Salary	140 12 6
Maintenance of Society's Library :—	
Binding and Repairing Books	24 11 3
£200 War Loan Stock	195 16 0
Transfers to Society's Funds	83 12 0
Balance at District Bank, 1st April, 1916	224 12 0
	£669 3 9

*** A cheque for M.541 sent to Germany at the end of July, 1914, has not been paid into the Bank and is therefore not included in these accounts; and there are outstanding accounts not paid amounting to £109. 14s. 3d.

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

W. Henry Todd, Treasurer, in Account with the Society, from 1st April, 1915, to 31st March, 1916.

Dr. **Cr.**

	£ s. d.	£ s. d.		£ s. d.	£ s. d.
To Balance, 1st April, 1915		108 16 8½	By Charges on Property :—		
To Members' Subscriptions :—			Chief Rent (Income Tax deducted)	11 4 0	
Half Subscriptions, 1909-10, 1 at £1. 1s. od.	1 1 0		Income Tax	1 18 8	
,, 1910-11, 1 ,, ,, ...	1 1 0		Insurance against Fire	11 0 0	
,, 1911-12, 1 ,, ,, ...	1 1 0		Insurance against Air Raids	11 10 0	
,, 1912-13, 1 ,, ,, ...	1 1 0		By House Expenditure :—		
,, 1913-14, 2 ,, ,, ...	2 2 0		Coals, Gas, Electric Light, Water, &c.	36 10 6½	35 12 3
,, 1914-15, 4 ,, ,, ...	4 4 0		Tea, Coffee, &c., at Meetings	19 18 0	
,, 1915-16, 8 ,, ,, ...	8 8 0		Cleaning, Sweeping Chimneys, &c.	4 9 2½	
Subscriptions :— 1911-12, 1 ,, £2. 2s. od.	2 2 0		Replacements of mantles, crockery, dusters, ironware, etc.	6 12 7½	
,, 1912-13, 1 ,, ,, ...	2 2 0		Whitewashing, repairs, etc.	4 10 6	
,, 1913-14, 3 ,, ,, ...	6 6 0		Cleaning Carpets	5 12 0	
,, 1914-15, 11 ,, ,, ...	23 2 0		By Administrative Charges :—		
,, 1915-16, 96 ,, ,, ...	201 12 0		Housekeeper		80 12 10½
		254 2 0	Postages, and Carriage of Parcels and of "Memoirs"	66 5 0	
To Transfers from the Wilde Endowment Fund	.. ..	33 12 0	Stationery, Cheques, Receipts, and Engrossing	40 5 6	
To Sale of Publications	.. ..	19 0 6½	Printing Circulars, Reports, Articles of Association, &c.	0 17 5	
To Sale of Publications to Manchester University Press	.. ..	12 10 0	Extra attendance at Meetings, and during housekeeper's holidays	5 11 0	
To Sale of Catalogue	.. ..	0 2 0	Insurance against Liability	6 3 0	
To Sale of Blocks to Manchester Corporation	.. ..	0 15 3	National Health Insurance Stamps	0 12 0	
To Dividends :—			Miscellaneous Expenses	4 8 4	
Natural History Fund	53 1 6			3 15 7½	
Joule Memorial Fund	11 17 8		By Renovation of Dalton Apparatus		139 18 1½
Wilde Endowment Fund	3 16 6		By Framing Dalton MSS.	.. ..	1 7 0
		68 15 10	By Publishing :—		
To Income Tax Refunded :—			Printing "Memoirs and Proceedings"	.. ..	1 16 3
Natural History Fund	6 1 3		Illustrations for "Memoirs" (except Nat. Hist. papers)	116 12 0	
Joule Memorial Fund	1 1 5		By Library :—	0 11 3	
Wilde Endowment Fund	32 16 4		Books and Periodicals (except those charged to Natural History Fund) ..		120 3 3
		39 19 0	Periodicals formerly subscribed for by the Microscopical and Natural History Section	15 5 3	
To National Health Insurance Act deductions	.. ..	2 3 7	By Natural History Fund :—	3 7 6	
			(Items shown in the Balance Sheet of this Fund below)		18 12 0
			By Joule Memorial Fund :—		
			(Items shown in the Balance Sheet of this Fund below)		22 12 0
			By Wilde Endowment Fund (Income Tax refunded)		20 16 4
			,, ,, ,, ,, (Dividend refunded)		32 16 4
			By Balance at Williams Deacon's Bank, 1st April, 1916		3 16 6
			,, ,, in Treasurer's hands	94 16 4	
				10 0 0	
					104 16 4
	£590 1 11				£590 1 11

NATURAL HISTORY FUND, 1915—1916. (Included in the General Account, above.)

	£ s. d.		£ s. d.
To Dividends on £1,225 Great Western Railway Company's Stock	53 1 8	By Balance against this Fund, 1st April, 1915	17 5 1
To Remission of Income Tax, 1915	6 1 3	By Natural History Periodicals	18 4 9
		By Illustrations for papers on Nat. Hist. in "Memoirs"	1 18 0
		By Binding Periodicals	2 10 0
		By Balance, 1st April, 1916	19 5 1
	£59 2 11		£59 2 11

JOULE MEMORIAL FUND, 1915—1916. (Included in the General Account, above.)

	£ s. d.		£ s. d.
To Balance, 1st April, 1915	34 14 6	By Conversion of £200 War Loan to 4½ % Stock	10 0 0
To Dividends on £100 East India Railway Company's 4 % Annuity Stock	5 7 1	By Expenses of Conversion of Stock	0 6 4
To Interest on £200 War Loan	6 10 7	By Special Lecture	10 10 0
To Remission of Income Tax, 1915	1 1 5	By Balance, 1st April, 1916	76 17 3
	£97 13 7		£97 13 7

WILDE ENDOWMENT FUND, 1915—1916.

	£ s. d.		£ s. d.
To Balance, 1st April, 1915	353 4 5	By Assistant Secretary's Salary	140 12 6
To Dividends on £7,500 Gas Light and Coke Company's Ordinary Stock	272 19 11	By Maintenance of Society's Library :—	
To Interest on £200 War Loan	3 16 6	Binding and Repairing Books	24 11 3
To Remission of Income Tax, 1915	32 16 4	By £200 War Loan Stock	195 16 0
To Bank Interest	6 6 7	By Transfers to Society's Funds	83 12 0
		By Balance at District Bank, 1st April, 1916	224 12 0
	£669 3 9		£669 3 9

*** A cheque for M.541 sent to Germany at the end of July, 1914, has not been paid into the Bank and is therefore not included in these accounts; and there are outstanding accounts not paid amounting to £109. 14s. 3d.

NOTE.—The Treasurer's Accounts of the Session 1915-1916 have been endorsed as follows:

April 6th, 1916. Audited and found correct.

We have also seen, at this date, the certificates of the following Stocks held in the name of the Society:—£1,225 Great Western Railway Company 5% Consolidated Preference Stock, Nos. 12,293, 12,294, and 12,323; £7,500 Gas Light and Coke Company Ordinary Stock (No. 8/1960); £100 East India Railway Company's 4% Annuity Stock (No. 4032); and the deeds of the Natural History Fund, of the Wilde Endowment Fund, those conveying the land on which the Society's premises stand, and the Declarations of Trust.

Leases and Conveyances dated as follow:—
22nd Sept., 1797.
23rd Sept., 1797.
25th Dec., 1799.
,, ,, ,,
22nd Dec., 1820.
23rd Dec., 1820.

Declarations of Trust:—
24th June, 1801.
23rd Dec., 1820.
8th Jan., 1878.

Appointment of New Trustees:—
30th April, 1851.

We have also seen Bankers' acknowledgment of the investment of £400 in the 4½ per cent. War Loan:—1 Bond for £200, No. 1964; and 2 Bonds for £100 each, Nos. 6594/5.

We have also verified the balances of the various accounts with the bankers' pass books.

(Signed) E. L. RHEAD.
W. C. JENKINS.

THE COUNCIL
AND MEMBERS
OF THE
MANCHESTER
LITERARY AND PHILOSOPHICAL SOCIETY.

Corrected to December 30th, 1916.

President.
SYDNEY J. HICKSON, M.A., D.Sc., F.R.S.

Vice-Presidents.
FRANCIS NICHOLSON, F.Z.S.
G. ELLIOT SMITH, M.A., M.D., F.R.S.
T. A. COWARD, F.Z.S., F.E.S.
W. W. HALDANE GEE, B.Sc., M.Sc.Tech., A.M.I.E.E.

Secretaries.
R. L. TAYLOR, F.C.S., F.I.C.
GEORGE HICKLING, D.Sc., F.G.S.

Treasurer.
W. HENRY TODD.

Librarian.
C. L. BARNES, M.A.

Other Members of the Council.
R. F. GWYTHER, M.A.
W. M. TATTERSALL, D.Sc.
FRANCIS JONES, M.Sc., F.R.S.E., F.C.S.
WILLIAM THOMSON, F.R.S.E., F.C.S., F.I.C.
MARY McNICOL, M.Sc.
D. THODAY, M.A.

Assistant Secretary and Librarian.
R. F. HINSON.

ORDINARY MEMBERS.

Date of Election.

1911, April 4. Adamson, Arthur, M.Sc.Tech., A.R.C.S., Lecturer in Physics in the Municipal School of Technology, Manchester. *The Municipal School of Technology, Sackville Street, Manchester.*

1901, Dec. 10. Adamson, Harold. *Oaklands Cottage, Godley, near Manchester.*

1912, Oct. 15. Adamson, R. Stephen, M.A., B.Sc., Lecturer in Botany in the Victoria University of Manchester. *The University, Manchester.*

1914, Dec. 1. Atack, F. W., M.Sc.Tech. (Manc.), B.Sc. (Lond.), F.I.C., Demonstrator in Chemistry, The Municipal School of Technology, Manchester. 88, *Claude Road, Chorltonville, Manchester.*

1865, Nov. 14. Bailey, Charles, M.Sc., F.L.S. *Haymesgarth, Cleeve Hill, S.O., Gloucestershire.*

1916, Feb. 2. Balls, W. Lawrence, Sc.D., Research Botanist to the Fine Cotton Spinners' Association St. James's Square, Manchester. *Bramhall, Cheshire.*

1895, Jan. 8. Barnes, Charles L., M.A. 151, *Plymouth Grove, Manchester.*

1903, Oct. 20. Barnes, Jonathan, F.G.S. *South Cliff House*, 301, *Great Clowes Street, Higher Broughton, Manchester.*

1910, Oct. 18. Beattie, Robert, D.Sc., M.I.E.E., Professor of Electrotechnics in the Victoria University of Manchester. *The University, Manchester.*

1895, Mar. 5. Behrens, Gustav. *Holly Royde, Withington, Manchester.*

1868, Dec. 15. Bickham, Spencer H., F.L.S. *Underdown, Ledbury.*

1914, Nov. 17. Bohr, Neils, Ph.D. (Copenhagen), Reader in Mathematical Physics in the Victoria University of Manchester. *The University, Manchester.*

1914, Dec. 1. Bowman, Frank, B.A. (Camb.), M.Sc.Tech. (Manc.), Assistant Lecturer in Mathematics, The Municipal School of Technology, Manchester. 21, *Whalley Road, Whalley Range, Manchester.*

1914, Feb. 10. Boyd, A. W., M.A., F.E.S. *The Alton, Altrincham, Cheshire.*

Date of Election.

1875, Nov. 16. Boyd, John. *Barton House*, 11, *Didsbury Park, Didsbury. Manchester.*

1915, Oct. 19. Bradley, F. E., M.A., M.Com., LL.D., F.R.S.E., Barrister-at-Law, *Stormarn, Wilbraham Road, Chorlton-cum-Hardy, Manchester*, and *Bank of England Chambers, Manchester.*

1886, April 6. Brown, Alfred, M.A., M.D. *Beech Hill, Hale, Cheshire.*

1913, Dec. 2. Brown, T. Graham, M.D., D.Sc., Lecturer in Experimental Physiology in the Victoria University of Manchester. *The University, Manchester.*

1889, Oct. 15. Budenberg, C. F., M.Sc., M.I.Mech.E. *Bowdon Lane, Marple, Cheshire.*

1911, Jan. 10. Burt, Frank Playfair, B.Sc. (Lond.), D.Sc. (Bristol), Senior Lecturer in Chemistry in the Victoria University of Manchester. 15, *Oak Road, Withington, Manchester.*

1906, Feb. 27. Burton, Joseph, A.R.C.S. Dublin. *Tile Works, Clifton Junction, near Manchester.*

1894, Nov. 13. Burton, William, M.A., F.C.S. *Carisbrook, Victoria Park, Manchester.*

1911, Oct. 31. Butterworth, Charles F. *Waterloo, Poynton, Cheshire.*

1904, Oct. 18. Campion, George Goring, L.D.S. 264, *Oxford Street, Manchester.*

1899, Feb. 7. Chapman, D. L., M.A., F.R.S., Fellow and Tutor of Jesus College, Oxford. *Jesus College, Oxford.*

1901, Nov. 26. Chevalier, Reginald C., M.A., Mathematical Master at the Manchester Grammar School. 3, *Fort Road, Sedgley Park, Prestwich, Manchester.*

1907, Nov. 26. Clayton, Robert Henry, B.Sc., Chemist. 1, *Parkfield Road, Didsbury, Manchester.*

1906, Oct. 30. Coward, H. F., D.Sc., Chief Lecturer in Chemistry in the Municipal School of Technology, Manchester. *Municipal School of Technology, Sackville Street, Manchester*, and 216, *Plymouth Grove, Manchester.*

1906, Nov. 27. Coward, Thomas Alfred, F.Z.S., F.E.S. *Brentwood, Bowdon, Cheshire.*

1908, Nov. 3. Cramp, William, D.Sc., M.I.E.E., Consulting Engineer, 33, *Brazennose Street, Manchester.*

1916, Oct. 31. Craven, Mrs. M. Badger, M.Sc., Demonstrator in Chemistry in the Municipal School of Technology, Manchester. 10, *Birch Grove, Rusholme, Manchester.*

Date of Election.

1910, Oct. 4. Crewe, F. H., Assistant Science Master in the Central High School for Boys, Whitworth Street, Manchester. *Glengarth, Woodford Road, Bramhall.*

1915, Nov. 16. Cutler, Donald Ward, B.A. (Cantab.), Scholar of Queens' College, Cambridge; Assistant Lecturer and Demonstrator in Zoology in the Victoria University of Manchester. *69, Mauldeth Road, Withington, Manchester.*

1895, April 9. Dawkins, W. Boyd, M.A., D.Sc., F.R.S., Honorary Professor of Geology in the Victoria University of Manchester. *Fallowfield House, Fallowfield, Manchester.*

1894, Mar. 6. Delépine, A. Sheridan, M.B., B.Sc., Professor of Pathology in the Victoria University of Manchester. *Public Health Laboratory, York Place, Manchester.*

1887, Feb. 8. Dixon, Harold Baily, M.A., Ph.D., M.Sc., F.R.S., F.C.S., Professor of Chemistry in the Victoria University of Manchester. *The University, Manchester.*

1906, Oct. 30. Edgar, E. C., D.Sc., Senior Lecturer in Chemistry in the Victoria University of Manchester. *The University, Manchester.*

1914, Nov. 3. Edwards, C. A., D.Sc., Professor of Metallurgy and Metallography in the Victoria University of Manchester. 26, *Lyndhurst Road, Withington, Manchester.*

1910, Oct. 18. Evans, Evan Jenkin, D.Sc. (Lond.), B.Sc. (Wales), A.R.C.Sc., Assistant Lecturer and Demonstrator in Physics in the University of Manchester. *The University, Manchester.*

1914, Feb. 24. Evans, William David, M.A., Richardson Lecturer in Mathematics, The Victoria University of Manchester. 17, *Harley Avenue, Victoria Park, Manchester.*

1912, Oct. 15. Fairlie, D. M., M.Sc. 232, *Burton Road, West Didsbury, Manchester.*

1914, Oct. 20. Field, Allan B., M.A., B.Sc., M.I.E.E., Professor of Mechanical Engineering, The Municipal School of Technology, Manchester. *Kingslea, Strines Road, Marple, Cheshire.*

1912, Feb. 6. Forder, H. G., B.A., Senior Mathematical Master, Cardiff High School. *St. Olave's Grammar School, Tower Bridge, London.*

Date of Election.

1908, Jan. 28. Fox, Thomas William, M.Sc.Tech., Professor of Textiles in the School of Technology, Manchester University. *Gledfield*, 15, *Clarendon Crescent, Eccles.*

1912, Oct. 15. Garnett, J. C. Maxwell, M.A., Principal of the Municipal School of Technology, Manchester. *The Municipal School of Technology, Sackville Street, Manchester*, and *Westfield, Victoria Park, Manchester.*

1909, Mar. 23. Gee, W. W. Haldane, B.Sc., M.Sc.Tech., A.M.I.E.E., Professor of Pure and Applied Physics in the School of Technology, Manchester University. *Oak Lea, Whalley Avenue, Sale.*

1907, Oct. 15. Gravely, F. H., M.Sc. *Natural History Dept., Indian Museum, Calcutta.*

1907, Oct. 29. Gwyther, Reginald Felix, M.A., Secretary to the Joint Matriculation Board. 24, *Dover Street, Manchester*, and *Ivy Cottage, Lymm, Cheshire.*

1915, Nov. 2. Hamlyn, G. A., B.A. (Oxon.), Assistant Lecturer and Demonstrator in the Fermentation Industries, The Municipal School of Technology, Manchester. *The Municipal School of Technology, Sackville Street, Manchester.*

1913, Dec. 16. Handley, Marion, M.A. (Birm.), Lecturer in the Municipal Day Training College, Manchester. *Himmel, Burnage Garden Village, Manchester.*

1911, Oct. 3. Hassé, H. R., M.A., D.Sc., Lecturer in Mathematics in the University of Manchester. 22, *Chatham Grove, Withington, Manchester.*

1914, Mar. 10. Hibbert, Eva, Assoc.M.S.T., Demonstrator in Chemistry, The Municipal School of Technology, Manchester. *The Municipal School of Technology, Manchester.*

1907, Oct. 15. Hickling, H. George A., D.Sc., F.G.S., Lecturer in Palæontology in the Victoria University of Manchester. *Glenside, Marple Bridge, near Stockport.*

1895, Mar. 5. Hickson, Sydney J., M.A., D.Sc., F.R.S., Professor of Zoology in the Victoria University of Manchester. *The University, Manchester.*

1905, Nov. 14. Holt, Alfred, M.A., D.Sc., Research Fellow of the University of Manchester. *Dowsefield, Allerton, Liverpool.*

1896, Nov. 3. Hopkinson, Edward, M.A., D.Sc., M.Inst.C.E. *Ferns, Alderley Edge, Cheshire.*

Date of Election.

1909, Feb. 9. Howles, Frederick, M.Sc., Analytical and Research Chemist. *Glenluce, Waterpark Road, Broughton Park, Manchester.*

1889, Oct. 15. Hoyle, William Evans, M.A., D.Sc., F.R.S.E., Director of the Welsh National Museum, Cardiff. *City Hall, Cardiff.*

1907, Oct. 15. Hübner, Julius, M.Sc Tech., F.I.C., Lecturer in the Faculty of Technology in the University of Manchester. *Linden, Cheadle Hulme, Cheshire.*

1913, Oct. 21. Imms, A. D., M.A., D.Sc., F.L.S., Reader in Agricultural Entomology in the Victoria University of Manchester. *Department of Agricultural Entomology, The University, Manchester.*

1914, Jan. 13. Jenkins, William Charles, F.R.A.S., Curator of the Godlee Observatory, The Municipal School of Technology, Manchester. *The Municipal School of Technology, Manchester.*

1911, Oct. 3. Johnstone, Mary A., B.Sc.(Lond.), Headmistress of the Municipal Secondary School for Girls, Whitworth Street, Manchester. 43, *Hill Top Avenue, Cheadle Hulme, Cheshire.*

1878, Nov. 26. Jones, Francis, M.Sc., F.R.S.E., F.C.S. *Manchester Grammar School*, and 17, *Whalley Road, Whalley Range, Manchester.*

1915, Mar. 9. Kearns, Henry Ward, B.Sc., J.P. *Boothroyd, Brooklands, near Manchester.*

1903, Feb. 3. Knecht, Edmund, Ph.D., Professor of Chemistry in the School of Technology, Manchester University. *Beech Mount, Marple, Cheshire.*

1893, Nov. 14. Lamb, Horace, M.A., LL.D., D.Sc., Sc.D., F.R.S., Professor of Mathematics in the Victoria University of Manchester. 6, *Wilbraham Road, Fallowfield, Manchester.*

1909, Nov. 2. Lang, William H., M.B., C.M., D.Sc., F.R.S., F.L.S., Barker Professor of Cryptogamic Botany in the University of Manchester. 2, *Heaton Road, Withington, Manchester.*

1902, Jan. 7. Lange, Ernest F., M.I.Mech.E., A.M.Inst.C.E., M.I. & S. Inst., F.C.S. *Westholme, The Firs, Bowdon, Cheshire.*

Date of Election.

1911, Jan. 10. Lankshear, Frederick Russell, B.A. (New Zeal.), M.Sc. (Manc.), Demonstrator in Chemistry in the Victoria University Manchester. *The University, Manchester.*

1910, Oct. 18. Lapworth, Arthur, D.Sc., F.R.S., F.I.C., Professor of Organic Chemistry in the Victoria University of Manchester. 26, *Broadway, Withington, Manchester.*

1914, April 7. Lees, S., M.A., Assoc.M.S.T., Reader in Applied Thermodynamics in the Faculty of Technology, The University of Manchester. *The Municipal School of Technology, Manchester*, and *Brierfield, Ashley Road, Hale, Cheshire.*

1907, Oct. 29. Leigh, Harold Shawcross. *Brentwood, Worsley.*

1912, Nov. 12. Lindsey, Marjorie, B.Sc., Research Student in the Victoria University of Manchester. ?, *Demesne Road, Whalley Range, Manchester.*

1912, May 7. Loewenfeld, Kurt, Ph.D. *Fern Bank, Ogden Road, Bramhall, Cheshire.*

1910, Oct. 18. McDougall, Robert, B.Sc. *City Flour Mills, German Street, Manchester.*

1905, Oct. 31. McNicol, Mary, M.Sc. 182, *Upper Chorlton Road, Manchester.*

1904, Nov. 1. Makower, Walter, M.A., D.Sc. (Lond.), Lecturer in Physics in the University of Manchester. *Maylands, Brook Road, Fallowfield, Manchester.*

1902, Mar. 4. Mandleberg, Goodman Charles. *Redclyffe, Victoria Park, Manchester.*

1911, Oct. 31. March, Margaret Colley, M.Sc. *The University, Edinburgh.*

1901, Dec. 10. Massey, Herbert. *Ivy Lea, Burnage, Didsbury, Manchester.*

1864, Nov. 1. Mather, Sir William, P.C., M.Inst.C.E., M.I.Mech.E. *Iron Works, Salford.*

1912, Nov. 26. Melland, Edward. *Kia Ora, Hale, Cheshire.*

1873, Mar. 18. Melvill, James Cosmo, M.A., D.Sc., F.L.S. *Meole Brace Hall, Shrewsbury.*

1915, Nov. 30. Miers, Sir Henry Alexander, M.A., D.Sc., F.R.S., Vice-Chancellor of the Victoria University of Manchester. *Birch Heys, Cromwell Range. Fallowfield, Manchester.*

1894, Feb. 6. Mond, Robert Ludwig, M.A., F.R.S.E., F.C.S. *Winnington Hall, Northwich, Cheshire.*

1915, Oct. 19. Munro, John Clegg. *Clough House, Whaley Bridge.*

Date of Election.

1912, Nov. 26. Myers, J. E., M.Sc., Beyer Fellow and Assistant Lecturer in Chemistry in the Victoria University of Manchester. 7, *Station Road, Cheadle Hulme, Cheshire.*

1908, Jan. 28. Myers, William, Lecturer in Textiles in the School of Technology, Manchester University. 7, *Station Road, Cheadle Hulme, Cheshire.*

1873, Mar. 4. Nicholson, Francis, F.Z.S. *Ravenscroft, Windermere, Westmorland.*

1884, April 15. Okell, Samuel, F.R.A.S. *Overley, Langham Road, Bowdon, Cheshire.*

1915, Oct. 19. Pemberton, William Granville, Technical Chemist. 49, *Acresfield Road, Pendleton.*

1901, Oct. 29. Petavel, J. E., B.A., D.Sc., F.R.S., Professor of Engineering in the Victoria University of Manchester. *The University, Manchester.*

1903, Dec. 15. Prentice, Bertram, Ph.D., D.Sc., Principal, Royal Technical Institute, Salford. *Isca Mount, Manchester Road, Swinton.*

1901, Dec. 10. Ramsden, Herbert, M.D. (Lond.), M.B., Ch.B. (Vict.) *Sunnyside, Dobeross, near Oldham, Lancs.*

1888, Feb. 21. Rée, Alfred, Ph.D., F.C.S. 15, *Mauldeth Road, Withington, Manchester.*

1913, Jan. 7. Renold, Hans, M.I.Mech.E. *Priestnall Hey, Heaton Mersey, near Manchester.*

1910, Oct. 4. Rhead, E. L., M.Sc.Tech., F.I.C., Lecturer in Metallurgy and Assaying, The Municipal School of Technology, Manchester. *Stonycroft, Polygon Avenue, Levenshulme, Manchester.*

1914, Nov. 3. Richardson, Harry, M.Sc., Demonstrator in Physics, The Municipal School of Technology, Manchester. 98, *Dudley Road, Whalley Range, Manchester.*

1912, Oct. 29. Roberts, A. W. Rymer, M.A. *The Common, Windermere.*

1880, Mar. 23. Roberts, D. Lloyd, M.D., F.R.S.E., F.R.C.P. (Lond.), *Ravenswood, Broughton Park, Manchester.*

Date of Election.

1911, Jan. 10. Robinson, Robert, D.Sc. (Vict.), Professor in the University of Liverpool. *The University, Liverpool.*

1916, Oct. 31. Robinson, Wilfred, M.Sc. (Manc.), B.Sc. (Lond.), Lecturer in Economic Botany in the Victoria University of Manchester. 23, *North Avenue, Garden Village, Levenshulme, Manchester.*

1897, Oct. 19. Rothwell, Alderman William Thomas, J.P. *Heath Brewery, Newton Heath, near Manchester.*

1916, Nov. 28. Rowe, Frederick Maurice, M.Sc., Research Chemist in Dyestuffs, The Municipal School of Technology, Manchester. 5, *Woodbine Terrace, Latchford.*

1907, Oct. 15. Rutherford, Sir Ernest, M.A., D.Sc., F.R.S., Langworthy Professor of Physics in the University of Manchester. 17, *Wilmslow Road, Withington, Manchester.*

1909, Jan. 26. Schmitz, Hermann Emil, M.A., B.Sc., Physics Master at the Manchester Grammar School. 15, *Brighton Grove, Rusholme, Manchester.*

1873, Nov. 18. Schuster, Arthur, Sc.D., Ph.D., Sec.R.S., F.R.A.S., Honorary Professor of Physics in the Victoria University of Manchester. *Yeldall, Twyford, Berks.*

1898, Jan. 25. Schwabe, Louis. *Hart Hill, Eccles Old Road, Pendleton, Manchester.*

1890, Nov. 4. Sidebotham, Edward John, M.A., M.B., M.R.C.S. *Erlesdene, Bowdon, Cheshire.*

1915, Nov. 28. Simon, Councillor Ernest Darwin. *Moorlands, Fog Lane, Didsbury, Manchester.*

1910, Oct. 4. Smith, Grafton Elliot, M.A., M.D., F.R.S., Professor of Anatomy in the University of Manchester. *The University, Manchester.*

1906, Nov. 27. Smith, Norman, D.Sc., Assistant Lecturer in Chemistry in the Victoria University of Manchester. *The University, Manchester.*

1896, Feb. 18. Spence, David. *Lowood, Hindhead, Haslemere, R.S.O., Surrey.*

1901, Dec. 10. Spence, Howard. *C/o Messrs. Peter Spence & Sons, Ltd., Manchester Alum Works, Manchester.*

1911, Oct. 17. Start, Laura, Lecturer in Art and Handicraft in the University of Manchester. *Moor View, Mayfield Road, Kersal, Manchester.*

Date of Election.

1897, Nov. 30. Stromeyer, C. E., M.Inst.C.E., M.Inst.M.E., M.I.&S.Inst. *Steam Users' Association*, 9, *Mount Street, Albert Square, Manchester*, and *Lancefield, West Didsbury.*

1910, Oct. 18. Tattersall, Walter Medley, D.Sc., Keeper of the Manchester Museum. *The Manchester Museum, The University, Manchester.*

1895, April 9. Tatton, Reginald A., M.Inst.C.E., Engineer to the Mersey and Irwell Joint Committee.

1893, Nov. 14. Taylor, R. L., F.C.S., F.I.C. *Central High School for Boys, Manchester*, and 37, *Mayfield Road, Whalley Range, Manchester.*

1911, Oct. 17. Thoday, D., M.A., Lecturer in Plant Physiology in the University of Manchester. *The University, Manchester.*

1911, Jan. 10. Thomson, J. Stuart, M.Sc. (Manc.), Ph.D.(Bern), F.R.S.E., F.L.S., Senior Demonstrator in Zoology in the Victoria University of Manchester. *The University, Manchester.*

1873, April 15. Thomson, William, F.R.S.E., F.I.C., F.C.S. *Royal Institution, Manchester.*

1896, Jan. 21. Thorburn, William, M.D., B.Sc. 2, *St. Peter's Square, Manchester.*

1899, Oct. 17. Todd, William Henry. *Greenfield, Parsonage Road, Flixton, near Manchester.*

1909, Jan. 26. Varley, George Percy, M.Sc. (Vic.), Central High School for Boys, Manchester. 19, *Mayfield Road, Whalley Range, Manchester.*

1912, Oct. 15. Walker, Miles, M.A., M.I.E.E., Professor of Electrical Engineering, the Municipal School of Technology, Manchester.

1873, Nov. 18. Waters, Arthur William, F.L.S., F.G.S. *Alderley, McKinley Road, Bournemouth.*

1906, Nov. 13. Watson, D. M. S., M.Sc. 60, *Lissenden Mansions, Highgate Road, London, N.W.*

1892, Nov. 15. Weiss, F. Ernest, D.Sc., F.L.S., Professor of Botany in the Victoria University of Manchester. *Easedale, Disley, Cheshire.*

Date of Election.

1909, Feb. 9. Weizmann, Charles, Ph.D., D.Sc., Reader in Bio-Chemistry in the Victoria University of Manchester. *The University, Manchester.*

1908, May 12. Welldon, Rt. Rev. J. E. C., D.D., Dean of Manchester. *The Deanery, Manchester.*

1911, Oct. 17. West, Tom, B.Sc., Chemist and Metallurgist. 101, *Spring Bank Street, Stalybridge, near Manchester.*

1901, Oct. 1. Wild, Robert B., M.D., M.Sc., F.R.C.P., Professor of Materia Medica and Therapeutics in the Victoria University of Manchester. 96, *Mosley Street, Manchester.*

1859, Jan. 25. Wilde, Henry, D.Sc., D.C.L., F.R.S. *The Hurst, Alderley Edge, Cheshire.*

1909, Jan. 26. Wolfenden, John Henry, B.Sc. (Lond.), A.R.C.S. (Lond.), Assistant Master in the Central High School for Boys, Whitworth Street, Manchester. 5, *Ashton Road East, Failsworth.*

1905, Oct. 31. Woodall, Herbert J., A.R.C.S. 32, *Market Place, Stockport.*

1860, April 17. Woolley, George Stephen. *Victoria Bridge, Manchester.*

1895, Jan. 8. Worthington, Wm. Barton, B.Sc., M.Inst.C.E. *Kirkstyles, Duffield, near Derby.*

N.B.—Of the above list the following have compounded for their subscriptions, and are therefore life members:—

Bailey, Charles, M.Sc., F.L.S.

Worthington, Wm. Barton, B.Sc., M.Inst.C.E.

HONORARY MEMBERS.

Date of Election.

1892, April 26. Abney, Sir William de W., K.C.B., D.C.L., D.Sc., F.R.S. *Rathmore Lodge, Bolton Gardens South, South Kensington, London, S.W.*

1894, April 17. Appell, Paul, Membre de l'Institut, Professor of Theoretical Mechanics. *Faculté des Sciences, Paris.*

1892, April 26. Baeyer, Adolf von, For. Mem. R.S., Professor of Chemistry in the University of Munich. 1, *Arcisstrasse, Munich.*

1886, Feb. 9. Baker, John Gilbert, F.R.S., F.L.S. 3, *Cumberland Road, Kew.*

1889, April 30. Carruthers, William, F.R.S., F.L.S. 44, *Central Hill, Norwood, London, S.E.*

1903, April 28. Clarke, Frank Wigglesworth, D.Sc. *United States Geological Survey, Washington, D.C., U.S.A.*

1866, Oct. 30. Clifton, Robert Bellamy, M.A., F.R.S., F.R.A.S., Professor of Experimental Philosophy in the University of Oxford. 3, *Barawell Road, Banbury Road, Oxford.*

1892, April 26. Curtius, Theodor, Professor of Chemistry in the University of Kiel. *Universität, Kiel.*

1892, April 26. Darboux, J. Gaston, Membre de l'Institut, Secrétaire perpétuel de l'Académie des Sciences, Doyen honoraire de la Faculté des Sciences. 3, *Rue Mazarine, Paris.*

1900, April 24. Dewar, Sir James, M.A., LL.D., D.Sc., F.R.S., V.P.C.S., Fullerian Professor of Chemistry at the Royal Institution. *Royal Institution, Albemarle Street, London, W.*

Date of Election.

1892, April 26. Edison, Thomas Alva. *Orange, N.J., U.S.A.*

1895, April 30. Elster, Julius, Ph.D. 6, *Lessingstrasse, Wolfenbüttel.*

1900, April 24. Ewing, Sir J. Alfred, K.C.B., M.A., LL.D., F.R.S., Director of Naval Education to the Admiralty. *The University, Edinburgh.*

1889, April 30. Farlow, W. G., Professor of Botany at Harvard College. *Harvard College, Cambridge, Mass., U.S.A.*

1900, April 24. Forsyth, Andrew Russell, M.A., Sc.D., LL.D., F.R.S. Professor of Mathematics at the Imperial College of Science and Technology. *The Imperial College of Science and Technology, S. Kensington, London.*

1892, April 26. Fürbringer, Max, Professor of Anatomy in the University of Heidelberg. *Universität, Heidelberg.*

1895, April 30. Geitel, Hans. 6, *Lessingstrasse, Wolfenbüttel.*

1894, April 17. Glaisher, J. W. L., Sc.D., F.R.S. *Trinity College, Cambridge.*

1894, April 17. Gouy, A., Corr. Memb. Inst. Fr. (Acad. Sci.), Professor of Physics in the University of Lyons. *Faculté des Sciences, Lyons.*

1900, April 24. Haeckel, Ernst, Ph.D., Professor of Zoology in the University of Jena. *Zoologisches Institut, Jena.*

1894, April 17. Harcourt, A. G. Vernon, M.A., D.C.L., F.R.S., V.P.C.S. *St. Clare, Ryde, Isle of Wight.*

1894, April 17. Heaviside, Oliver, Ph.D., F.R.S. *Homefield, Lower Warberry, Torquay.*

1892, April 26. Hill, G. W. *West Nyack, N.Y., U.S.A.*

1888, April 17. Hittorf, Johann Wilhelm, Professor of Physics at Münster, *Polytechnicum, Münster.*

1892, April 26. Klein, Felix, Ph.D., For. Mem. R.S., Corr. Memb. Inst. Fr. (Acad Sci.), Professor of Mathematics in the University of Göttingen. 3, *Wilhelm Weber Strasse, Göttingen.*

Date of Election.

1894, April 17. Königsberger, Leo, Professor of Mathematics in the University of Heidelberg. *Universität, Heidelberg.*

1902, May 13. Larmor, Sir Joseph, M.A., D.Sc., LL.D., F.R.S., F.R.A.S. *St. John's College, Cambridge.*

1892, April 26. Liebermann, C., Professor of Chemistry in the University of Berlin. 29, *Matthäi-Kirch Strasse, Berlin.*

1887, April 19. Lockyer, Sir J. Norman, K.C.B., LL.D., Sc.D., F.R.S., Corr. Memb. Inst. Fr. (Acad. Sci.). *Hill Observatory, Salcombe Regis, Sidmouth, Devon.*

1902, May 13. Lodge, Sir Oliver Joseph, D.Sc., LL.D., F.R.S., Principal of the University of Birmingham. *The University, Birmingham.*

1900, April 24. Lorentz, Henrik Anton, For. Mem. R.S., Corr. Memb. Inst. Fr. (Acad. Sci.), Professor of Physics in the University of Haarlem. *Zijlweg, 76, Haarlem.*

1892, April 26. Marshall, Alfred, M.A., formerly Professor of Political Economy in the University of Cambridge. *Balliol Croft, Madingley Road, Cambridge.*

1895, April 30 Mittag-Leffler, Gösta, D.C.L. (Oxon.), For. Mem. R.S., Professor of Mathematics in the University of Stockholm, *Djursholm, Stockholm.*

1910, April 5. Nernst, Geh. Prof. Dr. Walter, Director of the Physikal-Chemisches Institut in the University of Berlin. *Am Karlsbad 26a, Berlin W. 35.*

1902, May 13. Osborn, Henry Fairfield, Professor of Vertebrate Palæontology at Columbia College. *American Museum of Natural History, W. 77 Street, New York, U.S.A.*

1894, April 17. Ostwald, W., Professor of Chemistry. *Groszbothen, Kgr. Sachsen.*

Date of Election.

1899, April 25. Palgrave, Sir Robert H. Inglis, F.R.S., F.S.S. *Henstead Hall, Wrentham, Suffolk.*

1894, April 17. Pfeffer, Wilhelm, For. Mem. R.S., Professor of Botany in the University of Leipsic. *Botanisches Institut, Leipsic.*

1892, April 26. Quincke, G. H., For. Mem. R.S., Professor of Physics in the University of Heidelberg. *Universität, Heidelberg.*

1886, Feb. 9. Rayleigh, Right Hon. John William Strutt, Lord, O.M., M.A., D.C.L. (Oxon.), Sc.D. (Cantab.), LL.D. (Univ. McGill), F.R.S., F.R.A.S., Corr. Memb. Inst. Fr. (Acad. Sci.), Chancellor of the University of Cambridge. *Terling Place, Witham, Essex.*

1900, April 24. Ridgway, Robert, Curator of the Department of Birds, U.S. National Museum. *Brookland, District of Columbia, U.S.A.*

1902, May 13. Scott, Dukinfield Henry, M.A., LL.D., Ph.D., F.R.S., F.L.S. *East Oakley House, Oakley, Hants.*

1892, April 26. Thiselton-Dyer, Sir William T., K.C.M.G., C.I.E., M.A., Sc.D., Ph.D., LL.D., F.R.S. Lately Director Royal Botanic Gardens, Kew. *The Ferns, Witcombe, Gloucester.*

1895, April 30. Thomson, Sir Joseph John, O.M., M.A., Sc.D., F.R.S., Cavendish Professor of Experimental Physics in the University of Cambridge. *Trinity College, Cambridge.*

1894, April 17. Thorpe, Sir T. Edward, C.B., Ph.D., D.Sc., LL.D., F.R.S., V.P.C.S. *Whinfield, Salcombe, S. Devon.*

1886, Feb. 9. Tylor, Sir Edward Burnett, D.C.L. (Oxon), LL.D. (St. And. and McGill Univs.), F.R.S., formerly Professor of Anthropology in the University of Oxford. *Linden, Wellington, Somerset.*

Date of Election.

1894, April 17. Vines, Sidney Howard, M.A., D.Sc., F.R.S., F.L.S., Sherardian Professor of Botany in the University of Oxford. *Headington Hill, Oxford.*

1894, April 17. Warburg, Emil, Professor of Physics at the Physical Institute, Berlin. *Physikalisches Institut, Neue Wilhelmstrasse, Berlin.*

CHANGES OF ADDRESS.

Members are particularly requested to inform the Secretaries of any errors in their addresses or descriptions.

Awards of the Dalton Medal.

1898. EDWARD SCHUNCK, Ph.D., F.R.S.
1900. Sir HENRY E. ROSCOE, F.R.S.
1903. Prof. OSBORNE REYNOLDS, LL.D., F.R.S.

THE WILDE LECTURES.

1897. (July 2) "On the Nature of the Röntgen Rays." By Sir G. G. STOKES, Bart., F.R.S. (*28 pp.*)

1898. (Mar. 29.) "On the Physical Basis of Psychical Events." By Sir MICHAEL FOSTER, K.C.B., F.R.S. (*46 pp.*)

1899. (Mar. 28) "The newly discovered Elements; and their relation to the Kinetic Theory of Gases." By Prof. WILLIAM RAMSAY, F.R.S. (*19 pp.*)

1900. (Feb. 13.) "The Mechanical Principles of Flight." By the Rt. Hon. LORD RAYLEIGH, F.R.S. (*26 pp.*)

1901. (April 22.) "Sur la Flore du Corps Humain." By Dr. ELIE METSCHNIKOFF, For.Mem.R.S. (*38 pp.*)

1902. (Feb. 25.) "On the Evolution of the Mental Faculties in relation to some Fundamental Principles of Motion." By Dr. HENRY WILDE, F.R.S. (*34 pp., 3 pls.*)

1903. (May 19.) "The Atomic Theory." By Professor F. W. CLARKE, D.Sc. (*32 pp.*)

1904. (Feb. 23.) "The Evolution of Matter as revealed by the Radio-active Elements." By FREDERICK SODDY, M.A. (*42 pp.*)

1905. (Feb. 28.) "The Early History of Seed-bearing Plants, as recorded in the Carboniferous Flora." By Dr. D. H. SCOTT, F.R.S. (*32 pp., 3 pls.*)

1906. (March 20.) "Total Solar Eclipses." By Professor H. H. TURNER, D.Sc., F.R.S. (*32 pp.*)

1907. (February 18.) "The Structure of Metals." By Dr. J. A. EWING, F.R.S., M.Inst.C.E. (*20 pp., 5 pls., and 5 text-figs.*)

1908. (March 3.) "On the Physical Aspect of the Atomic Theory." By Professor J. LARMOR, Sec. R.S. (*54 pp.*)

1909. (March 9.) "On the Influence of Moisture on Chemical Change in Gases." By Dr. H BRERETON BAKER, F.R.S. (*8 pp.*)

1910. (March 22.) "Recent Contributions to Theories regarding the Internal Structure of the Earth." By Sir THOMAS H. HOLLAND, K.C.I.E., D.Sc., F.R.S.

SPECIAL LECTURES.

1913. (March 4.) "The Plant and the Soil." By A. D. HALL, M.A., F.R.S.

1914. (March 18.) "Crystalline Structure as revealed by *X*-rays." By Professor W. H. BRAGG, M.A. F.R.S.

1915. (May 4th.) "The Place of Science in History." By Professor JULIUS MAC LEOD, D.Sc.

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1782-1786.	James Massey, Thomas Percival, M.D., F.R.S.
1787-1789.	James Massey.
1789-1804.	Thomas Percival, M.D., F.R.S.
1805-1806.	Rev. George Walker, F.R.S.
1807-1809.	Thomas Henry, F.R.S.
1809.	*John Hull, M.D., F.L.S.
1809-1816.	Thomas Henry, F.R.S.
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* Elected April 28th; resigned office May 5th.

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Washington.—United States Geological Survey. Geologic Atlas of the United States. Folios Nos. 195-198. Washington, D.C., 1915. (*Recd. 28/vii./16.*)

———.—**Washington State Commission, Alaska-Yukon-Pacific Exposition.** Check-List of Books and Pamphlets relating to the History of the Pacific Northwest. By Charles W. Smith. Olympia, Washington, 1909. (*Recd. 24/vii./16.*)

Wellington.—New Zealand Institute. Transactions and Proceedings of the New Zealand Institute. Vols. 1-47. Wellington, N.Z., 1869-1915. (*Recd. 30/v./16.*)

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